TEXTILE RESEARCH

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The Editor's Page

THE papers, addresses and other proceedings of the annual meeting, research conference and dinner are published completely in this issue, with the exception of the discussion of the papers by Mr. Ross and Dr. Farr. Outline reports of these discussions will be published in the next issue, and if there is a sufficient demand from members for copies of the stenographic report they will be made available at cost price.

FOR the benefit of new members, we wish to emphasize the fact that the Secretary's office is prepared to aid them in securing complete copies of articles listed in the Abstract Section of this magazine. Photostat copies can be furnished at cost of articles that are in periodicals which are on file in the Institute's library or in other local libraries. For certain periodicals not available in these libraries it is possible to refer inquirers to other libraries where they may be referred to. In all cases the addresses of publishers of abstracted periodicals can be provided. The number of members making systematic use of this Institute service is increasing steadily.

The Subject of Congratulations

OFFICERS and directors of U. S. Institute for Textile Research have been the recipients of many congratulations since the recent annual meeting on the latter's demonstration of the valuable program of research that the Institute is now engaged upon. The congratulations are highly appreciated; particularly the accompanying opinion that no difficulty should now be experienced in securing the personal and financial co-operation of textile men who have confidence in the future of the industry.

The Institute was incorporated as a non-profit Membership Corporation under New York State laws and commenced work in 1930 with a very definite program: "To promote, cultivate and facilitate scientific research in connection with the production of textile raw materials and their utilization in the textile manufacturing industries of the United States."

Its steady growth in services and membership has been due largely to a comparatively small group of men who have served on its Board of Directors and Research Council because they believe in research for themselves as well as for the industry as a whole, and who believe that it can be provided for the industry most economically and resultfully on a co-operatively financed basis without the expenditure of large sums on buildings, laboratories and other capital assets.

Until 1935 it had to be satisfied to place its research with university and other laboratories which had facilities and funds for the work, and could be induced to undertake it. In 1935 the warp sizing study was financed co-operatively, with members and the Textile Foundation each subscribing $5,000. Meantime, however, the Research Council had been planning additional studies. The Committee on Economic Research, for instance, had

(*Continued on P. 102*)

Seventh Annual Meeting

Research Conference and Dinner Speaking Program the Notable Features

UNDOUBTEDLY attendance at the seventh annual meeting of U. S. Institute for Textile Research, Inc., Thursday, Nov. 5, at the Waldorf-Astoria, New York, N. Y., would have been larger had there not been the counter-attraction of an election holiday on the preceding Tuesday; however, the audience of 100 at the afternoon research conference and that of 115 at the dinner presented conclusive evidence by their numbers and their interest in the proceedings that political victory or defeat do not blind them to the importance of research as an industrial factor.

Among the most notable features of the various functions were the following: At the afternoon research conference the presentation of the revised and enlarged program for the textile drying research, the paper by John O. Ross, president, Ross Engineering Corp., New York, N. Y., on "Some Drying Problems in Other Industries Than the Textile Industry," and the paper illustrated with lantern slides presented by Dr. Wanda K. Farr, of Boyce Thompson Institute for Plant Research, on "A New Viewpoint in the Study of Cellulosic Textile Fibres"; at the annual dinner the addresses of Dean Joseph H. Willits of the Wharton School of Finance and Commerce on a "Survey of Production and Distribution Organization in the Textile Industry," and that of Dr. E. H. Killheffer, vice-president of U. S. Institute on "Why Textile Research?"

The papers presented by Mr. Ross and Dr. Farr at the afternoon research conference were both followed by extended discussion. Chairman W. E. Emley of the Research Council was unable to be present and preside at the conference owing to the death of his mother. Dr. H. DeW. Smith, vice-chairman of the Council, presided and presented and explained the revised program of the textile drying study. The administration committee for this study consists of W. E. Emley, chairman; Alban Eavenson and Dr. H. DeW. Smith.

Officers and Directors Elected

TWO meetings of the Board of Directors and Executive Committee were held during the day, one prior to the annual meeting of the corporation at which interim reports were presented, and another following the corporation meeting at which officers and members of the Executive Committee were elected. The report of the committee on nominations (W. E. Emley, chairman, Alban Eavenson and H. DeW. Smith) was presented to the annual meeting and to the following meeting of the Board of Directors by Alban Eavenson in the absence of Chairman Emley. Their reports to both meetings were accepted and adopted unanimously.

Directors elected for terms expiring in 1939 were as follows: John W. Arrington, Pres., Union Bleachery, Greenville, S. C.; H. M. Chase, Research Director, Riverside & Dan River Cotton Mills, Danville, Va.; Daniel E.

Douty, Pres., U. S. Testing Co., Inc., Hoboken, N. J.; W. E. Emley, National Bureau of Standards, Washington, D. C.; Ephraim Freedman, Director, Bureau of Standards, R. H. Macy & Co., New York, N. Y.; H. Grandage, Vice-Pres., Clark Thread Co., New York, N. Y.; G. E. Hopkins, Technical Director, Bigelow-Sanford Carpet Co., Thompsonville, Conn.; E. R. Schwarz, Mass. Institute of Technology, Cambridge, Mass. Succeeding Joseph Bancroft, deceased, for a term expiring in 1937, John Bancroft, Jr., Pres., Joseph Bancroft & Sons Co., Wilmington, Del.; Succeeding W. Scott Libbey, resigned, for a term expiring in 1938, Fessenden S. Blanchard, chairman of U. S. Institute's Committee on Economic Research, and associated with Pacific Mills, New York, N. Y.

John Bancroft, Jr., was elected to succeed Joseph Bancroft, deceased, as a member of the Executive Committee and all other members were re-elected as follows: E. H. Killheffer, Chairman, Alban Eavenson, Warren E. Emley, Ernest N. Hood, Philip A. Johnson, Robert E. Rose, Edward R. Schwarz, Harold DeW. Smith.

The following officers were re-elected: President, Hon. Francis P. Garvan; Vice-presidents: E. H. Killheffer, Alban Eavenson, Louis A. Olney, Edward R. Schwarz, Harold DeW. Smith; Treasurer, Ernest N. Hood; Secretary, Charles H. Clark.

Annual Meeting of the Corporation

IN the absence of the President the annual meeting of the corporation was called to order by Executive Vice-President Killheffer at 11 A.M. in the Jansen Suite. The Secretary reported the attendance in person of more than a legal quorum, and the meeting was declared ready for business and the following agenda was then acted upon:

1. Minutes of last meeting.
2. Report of Board of Directors.
3. Report of Treasurer.
4. Report of Auditor.
5. Report of Secretary.
6. Report of Research Council.
7. Report of Nominating Committee.
8. Election of New Directors.
9. New Business.

(1) Minutes of the last meeting having been received by all members were accepted without reading.

(2) Report of the Board of Directors, as read by the Chairman, was accepted and ordered filed.

(3) The report of the Treasurer, as read by the Secretary, was accepted. (Treasurer reported receipts of $18,145.31, and expenses of $15,666.63, leaving a debit balance of $2,478.68. The balance sheet showed assets of $4,879.96, and cash and accrued interest for current use of $2,879.96.)

(4) The report of Auditor W. W. Buffum was accepted and ordered filed.

(5) Report of the Secretary was approved and ordered filed.

(6) In the absence of Chairman Emley of the Research Council an extemporaneous report was presented by Vice-Chairman Smith as follows:

Report of the Research Council

SINCE the last annual meeting the Research Council has held four meetings. In addition to actions and reports on the warp sizing project, the economic research project, and the organizing of a conference on drying and a research plan for this new project, the Council has examined a number of other suggestions for research which have been placed before it and has taken appropriate action on each. An effort was made to interest some of the schools and universities in some of the problems suggested.

The Council has recommended to the Board of Directors that a new edition of "Textile Research: A Survey of Progress" be published under the title "Textile Research Progress," this to be a review for the five year period ending with 1936.

Economic Research: Mr. Blanchard, chairman of the committee on economic research, will report in detail on this project and Dean Willits of the Wharton School of Finance and Commerce will be present this evening to speak on progress of the survey.

Drying Research Program: On May 6 the Research Council held an open conference on textile drying problems at which the registered attendance was 143. The papers on this subject stimulated a lively discussion and at the close of the conference there was an almost unanimous vote that the Institute should undertake a research project on this problem. Accordingly, a tentative program was drawn up and sent to those who attended the meeting. Since then the committee on drying research has enlarged this program, and this received the approval of the Directors at their meeting Sept. 23, and is to be presented for further discussion at the open conference this afternoon. To date your Secretary reports that 25 co-operators have signed up for this drying research project; wool and rayon manufacturers and drying machinery builders being the most numerous classes of subscribers thus far.

Warp Sizing: Four confidential reports have been sent to co-operators. A fifth is in preparation. In January the emphasis was shifted from the study of starches to rayon sizing. Two conferences were held at which a mill-scale study of sizing rayon was worked out in detail. In March Dr. W. E. Yelland was named director of the warp sizing research and Dr. Katz was retained in an advisory capacity. Two assistants were employed to carry out the chemical and physical testing and analysis at the M. I. T. laboratory in connection with the mill sizing program.

The Research Council welcomes constructive criticism and suggestions for research projects of interest to the members of the Institute. Your co-operation in bringing to us the problems of your own particular field is the surest way to help the Institute to demonstrate its ability to serve the industry.

Vice-Chairman Smith then called upon Chairman Blanchard of the Committee on Economic Research and the latter reported as follows:

Report of Committee on Economic Research

IN my report of November 8, 1935, I pointed out that on November 1st our Committee had proposed to the Textile Foundation an important study in the field of production and distribution organization in the textile

industry. I am glad to be able to report that on April 15, 1936, this study was approved by the Textile Foundation and that the Foundation has appropriated a sum, not to exceed $20,000, to cover the work. The administration of this study was placed in the hands of our Committee, in co-operation with the presidents of the four following textile associations, with whose approval the study was submitted:

National Association of Wool Manufacturers
Cotton-Textile Institute
Association of Cotton Textile Merchants of New York
National Federation of Textiles, Inc.

The purpose and scope of this survey as defined in the revised proposal finally submitted is as follows: "It is recommended that a case study be undertaken of significant developments in the organization of textile production and marketing. This would involve, particularly, investigation into the factors affecting the success or failure of various types of organization which have undertaken, at any important point, to bridge the gap between mill and consumer. By this is meant—not only the extension of financial control over additional steps or functions—but also developments which have been effective in bringing into closer co-ordination the production and marketing operations in the textile industry. The study would be based, not on theoretical considerations, but on the actual experience of a number of companies—both within and outside the textile industry.

"There are many important examples of such developments—mills which manufacture garments, garment manufacturers who have bought mills or who control retail stores, wholesalers who convert their own goods, mills or converters who have worked out close co-operative arrangements with wholesale or retail distributors, etc. Some appear to have succeeded; some have not. It is important for the textile industry to learn of the causes of failure as well as of the conditions of success. In the last analysis, each company in the textile industry must decide on the policy best suited to its own situation. But it would be of great value to companies, small as well as large, to have a ground work of facts, based on an unbiased survey, to guide them in more intelligently dealing with their own situation."

The selection of the agency to conduct the survey was left in the hands of our Committee, in co-operation with the presidents of the four above associations. The Wharton School of the University of Pennsylvania was selected and has been hard at work since June interviewing leaders in the industry and obtaining information bearing on all phases of this study. As an evidence of the fine spirit of co-operation shown by the Wharton School, Dean Willits of this school has stated to the writer that the school itself expected to contribute a substantial sum in the time of its staff and personnel beyond that covered by the appropriation from the Textile Foundation.

Since the survey started, we have obtained the hearty co-operation of leading associations from almost every branch of the textile industry. This includes the following associations, in addition to those originally sponsoring the study, to whom reference has already been made:

International Association of Garment Manufacturers
National Association of Finishers of Textile Fabrics
National Association of Hosiery Manufacturers
National Knitted Outerwear Association
National Rayon Weavers Association
Textile Fabrics Association
Underwear Institute
Wholesale Dry Goods Institute, Inc.

It is expected that the study will take from 15 to 18 months to complete and members of the Committee on Economic Research are all assisting in every way possible in the conduct of this survey.

(7) Mr. Eavenson reported for the nominating committee the list of directors for terms expiring at this meeting as previously noted.

(8) On motion duly made and seconded the report of the nominating committee was accepted and the Secretary was ordered to cast one ballot for the list; this having been done the Chairman declared the list elected as reported.

(9) No new business being reported, the meeting was adjourned at 12:15 P.M.

Annual Report of Board of Directors

YOUR Board of Directors held four regular quarterly meetings during the fiscal year 1935–36, as follows: Nov. 14, 1935; Mar. 3, June 3 and Sept. 23, 1936; also two special meetings, one in conjunction with the conference on textile drying, May 6, and one this morning. All but the March 3 meeting, which was in Washington, D. C., were held in New York City.

At the first quarterly meeting the following officers and members of the Executive Committee were elected and their acceptances were received: President, Hon. Francis P. Garvan; Vice-Presidents: E. H. Killheffer, Alban Eavenson, Louis A. Olney, Edward R. Schwarz, Harold DeW. Smith; Treasurer, Ernest N. Hood; Secretary, Charles H. Clark; Executive Committee: E. H. Killheffer, Chairman, Joseph Bancroft, Alban Eavenson, Warren E. Emley, Ernest N. Hood, Philip A. Johnson, Robert E. Rose, Edward R. Schwarz, Harold DeW. Smith.

Your books of account have been audited by Mr. William W. Buffum and his certificate of their correctness has been accepted and filed. Your Treasurer's report as of Sept. 30 shows a gratifying increase in our small cash balance of current funds. Your budget for the last fiscal year predicted income, expense and debit balance items within a few hundred dollars, the balance underestimated by about $200. It is hoped that the budget for the current fiscal year, estimating a further increase in our modest debit balance, will prove equally conservative.

The authorized purposes of the corporation are to promote, cultivate and facilitate research in the textile industries of the United States. Until last year the general business depression restricted our efforts largely to those of a promotional or educational character. Without a review of the results of this effort you will find circumstantial evidence of its effectiveness in the steady growth of our membership and in the circulation of our magazine. Efforts to facilitate the financing of our own research were un-

successful until last year when the co-operative financing of the warp sizing study was completed, with the aid of the Textile Foundation on a 50–50 basis. Since the start of actual work on this study, June 1, 1935, we have had research work of our own to cultivate. Encouraged to believe that our Research Council and Executive Committee had developed methods and defined policies by which research personnel, facilities and results could be provided to the industry at a fraction of its cost to an individual mill by any other method, your Research Council proceeded last May to publicize by its conference method the need of a scientific study of textile drying. The largely attended conference voted almost unanimously that the Institute should undertake the organization and co-operative financing of such a study. Progress to date has been encouraging, and it is hoped that methods may be developed at this meeting for early completion of the financing and starting of the work.

Economic Research

Although the promotion of economic research is not specifically provided for in our charter, it has been recognized that this was unnecessary, as it is an essential corollary of scientific research. For several years we have had a sub-committee of our Research Council on economic research. The potential value of its activities was recognized by its continuance when all other original sub-committees were deleted. We are indebted to this committee for the most important research accomplishment of the year. We refer to the "Survey of Production and Distribution Organization in the Textile Industry" which they planned and will supervise with the aid of an advisory committee of leading association officials, which has the co-operation of most of the other leading associations, is financed by the Textile Foundation for $20,000, and which has been in progress since last June under the direction of Dean Jos. H. Willits of the Wharton School of Finance and Commerce, University of Pennsylvania.

Three Types of Research

It will be seen that we are now prepared to promote, and are promoting, cultivating and facilitating three types of researches: (1) Studies selected by the Research Council and recommended to educational and other institutions having the requisite personnel, facilities and finances, the Council acting in an advisory capacity and undertaking to publish reports of results, if found worthy; (2) the organization, promotion and supervision of studies wholly financed by a foundation, a company, an individual, or by U. S. Institute, and the publication of results of such studies; (3) the organization, promotion and administration of co-operatively financed researches, the reports of which during progress shall be available only to contributors, and shall not be published until one year after completion of the study.

The revised program of the drying research, to be presented and explained at our research conference today by the committee in charge, will make public an additional type of service to be provided by co-operatively financed projects which should be of particular importance to mills lacking research personnel. Undoubtedly additional services may be made possible in the future, and it is quite probable that modifications of present research policies, or entirely new policies, may be found advisable. This is the only

textile organization of its kind. The services of its officers, with one exception, are donated to the industry. It lacks precedents to guide the development of its plans and policies. While only seven years old, it has gained a lot of specialized experience, and its Research Council includes men of broad experience in textile research. Your Directors believe that their action last year in delegating the responsibility for its research activities to a relatively small Research Council has been highly resultful; also that in relying largely upon a relatively small Executive Committee for the conduct of its other affairs it acted wisely.

Services to Contributing Members

Although you have already been notified, in a circular issued by the Secretary, of an important restriction in services to contributing members, starting Jan. 1, 1937, we wish to record and briefly explain this action of our meeting of Sept. 23, which was as follows:

> "Voted: That on and after Jan. 1, 1937, contributing membership in U. S. Institute for Textile Research, Inc., shall entitle the accredited representative of that membership, during the year covered by paid dues, to receive the confidential progress reports of any one co-operatively financed research of the Institute which may then be in progress, and that there shall be no limit to the number of contributing memberships which may be held by any one individual or company, each of which contributing memberships entitle the holder or the accredited representative of his company to receive confidential progress reports of any one of the co-operatively financed researches of the Institute that may be in progress; the preceding with the following exceptions: (1) that present contributing members who renew those memberships prior to Jan. 1, 1937, and new contributing members whose dues are paid prior to Jan. 1, 1937, shall have the privilege during the fiscal year 1936–37 of receiving confidential progress reports of all co-operatively financed researches of the Institute that may then be in progress."
>
> "Voted: That confidential progress reports of a co-operatively financed research of U. S. Institute for Textile Research, Inc., shall not be made public in printed or any other form until one year after completion of that research."

Actually, no official policy as to the confidential reports of co-operatively financed researches existed prior to the financing of the warp sizing study, which was the first of this type. The membership booklet published in the spring of 1935 contained the only published reference to U. S. Institute's policy of giving contributing members reports of all researches, and at that time there were no co-operatively financed studies and no confidential reports restricted to contributing members. The granting to all contributing members of the privilege of receiving the confidential progress reports of the warp sizing study during the period covered by paid dues was a fair and

logical procedure. However, when two contributing members and one life member each subscribed an additional $100 to this project it was seen that in fairness to them some additional reward should be granted and they were given extra contributing memberships. Thus far in the financing of the drying project nine additional contributing members have subscribed, and each will qualify for an additional contributing membership. But according to prior unofficial offers all contributing members holding one membership of this class would qualify to receive confidential progress reports of all researches, including those co-operatively financed, without contributing specifically to any one of them. Undoubtedly this generosity has restricted subscriptions to the drying project as it did to the warp sizing project. Eventually, it would seriously handicap the financing of all co-operatively financed studies. In terminating this unrestricted service to contributing members, your directors have endeavored to go the limit in liberality, and contributing members have been given until Jan. 1, 1937, to pay their dues and qualify to receive confidential reports of both co-operatively financed studies during the current fiscal year. To encourage completion of the financing of the drying project the same privilege is open to annual members and prospective members.

Definite specification of one year from date of completion of a co-operatively financed study for open publication of research findings represents no actual change in policy.

To Publish New Book

Upon recommendation of the Research Council we have authorized the publication of a successor to our book Textile Research: A Survey of Progress, which was published in 1932 and is now nearing the obsolescence point. The new book will report textile research progress for the five years from 1931. The Board of Editors of your magazine will have charge of planning and compiling the text, and the Publications Committee will supervise printing and marketing. Nearly 2,000 copies of the old book were distributed and there is ample evidence that it has performed a useful service.

Your Secretary is reporting on membership, the magazine, the status of the financing of the textile drying study, and other matters for which he is directly responsible, and no recapitulation here is necessary.

We wish to record formally our appreciation of the generous support by the Textile Foundation of the financing of the survey of trends in manufacturing and merchandising organization, and also of the co-operation in this project by the officials of leading textile associations. Our thanks, and those of all who benefit by our magazine, *Textile Research*, are also due to the Textile Foundation for continuation of the agreement that makes its publication possible.

We also extend to President Garvan and Treasurer Buffam of the Chemical Foundation our thanks and appreciation of their continued services and support.

It is with deep regret that we record the passing, May 6, of Mr. Joseph Bancroft, an original member, Director and member of the Executive Committee; also of another original member, Mr. George L. Gilmore, who was one of those who had an active part in the organization of U. S. Institute.

Secretary's Annual Report

YOUR Secretary's report supplements that of your Board of Directors in a little more detail, and covers certain of his work merely referred to by them; this in addition to the routine work of the Secretary's office. It will be appreciated that the latter has been materially increased by work incident to the financing and renewal of subscribers to co-operative researches, and by the preparation of confidential progress reports for mailing to co-operators. Also, there have been numerous conferences with the directors of the warp sizing study, and several with the administration committee and its chairman: although your Secretary has no official connection with this research work or its administration, he provides clerical and other aid when requested. More frequent meetings than in previous years of the Directors or Executive Committee and of the Research Council were held during the year under review, and these together with the research conference in May, and the annual dinner, both of which seem to have become regular functions, are additional routine work. These increased activities are outlined because they reflect, although inadequately, the expanded services that are now available to members and to all representatives of the industry who will avail themselves of them.

Memberships

Contributing memberships, and subscribers to co-operatively financed researches are the principal source of our current funds and of our research funds, and their solicitation and renewal are major duties of the Secretary. Subscribers to co-operative researches at $100 a year are, as you know, given contributing membership at no extra charge. There is this distinction, however: Regular contributing memberships are for our fiscal year, starting Oct. 1, while contributing memberships of co-operators in specific research projects are accepted for the year of that particular research. The initial and renewal date for the warp sizing project memberships is May 1. That for the drying project will not be determined until its financing is completed. I mention this situation for two reasons: (1) Because our Treasurer keeps a separate account for co-operatively financed researches and credits dues of financers to those accounts, and not to contributing memberships; (2) because none of the present 25 subscribers to the drying project can be classified as contributing members until 50, or a total of $5,000 have been secured; and this despite the fact that several of the subscribers have already paid their subscriptions or dues.

As of Sept. 30, my books showed 69 paid contributing memberships—one less than for the same date of 1935. Nine of these were new; 10 had not been renewed, but five of the latter are not classified as definitely lost. Renewals since Sept. 30 have been much better than usual; contributing membership renewals as of Oct. 30 having been 80%, and those of annual members 60% of the Sept. 30 totals.

Of a net loss Sept. 30 of 14 annual members, the majority were due to causes mentioned last year: transfers to contributing membership, and resignations because of receiving the magazine as one of the five representatives of a contributing member. Unrenewed annual members num-

bered 35 on Sept. 30, and new annual memberships 21, the total on that date being 194.

Our total paid membership as of Sept. 30 not including the 24 subscribers of that date to the drying project (several of whom have paid), was 265, as compared with 280 at the close of the 1935 fiscal year. This is the first time that we have been obliged to report a loss in total membership, even though that loss may be statistical and not actual. It may be actual if we are unable to complete the financing of the drying project.

For the current fiscal year we have budgeted an increase in annual membership to 200, and in the contributing class to 110. As completion of the drying project financing will bring in 50 new contributing members this estimate may be found conservative. In this connection we would call attention to the fact that until Jan. 1, 1937, as explained in your Directors' report, present contributing members who renew for the current year, and new contributing members whose dues are paid prior to that date, will qualify for the current fiscal year to receive confidential progress reports of all of our co-operatively financed researches: the warp sizing and the drying studies. Thereafter, contributing members will receive the confidential reports of but one co-operatively financed study.

The Magazine, *Textile Research*

An increase of over 60% in the paid subscriptions to our monthly magazine, *Textile Research*, is a gratifying recognition of its value, but to the extent that subscriptions are displacing annual memberships this is not so gratifying. The same statement might apply to the 203 copies that are going to representatives of companies holding contributing memberships. If more general advantage were taken of the latter privilege, which grants five free copies to representatives of a contributing member company, its influence in restricting our annual membership would be still more serious. The extent of such restriction is difficult to estimate accurately, but traceable losses have been considerable, as previously noted.

Our magazine mailing list as of Sept. 30 compared as follows with that for the end of the 1935 fiscal year:

	Sept. 30, 1936	*Sept. 30, 1935*
To Members	254	275
Representatives of Contributing Members	203	185
Paid Subscriptions	109	69
Exchange List	66	58
	632	587

As I have advanced the opinion in previous annual reports that our magazine circulation is a more accurate yard-stick by which to measure the industry's interest in research, and possibly the influence and standing of this organization, than is its paid membership, additional analysis of these figures may be of interest. Paid subscriptions are classified as follows: To domestic companies and individuals, 44; to libraries, 29; foreign, 36. The exchange list also includes a number of foreign research organizations and publications. Were all contributing members to take advantage of the privileges of having any five of their representatives receive the magazine the number of copies thus utilized would be 276 instead of 203.

Several companies having more than one contributing membership have failed to ask for additional copies for which they qualify. This also explains why the number of copies going to members was less than the membership.

Increased circulation, and provision for future demand for back copies, have necessitated an increase in copies of each issue printed to 750. The 12 issues of the last fiscal year contained 564 text pages, of which 439 pages were devoted to research reports, editorials and miscellaneous articles, and 117 pages and 698 items to the research abstract section. Of the original research reports published 21 were those of Textile Foundation Fellows, and 22 those of other contributors. The June and August issues, as you will recall, carried the papers and discussion of the drying conference held last May.

The magazine is one of very few scientific periodicals that is published without revenue from advertising. Were it not for the arrangement with the Textile Foundation by which the latter pays upon an arbitrarily agreed cost basis for space used for publication of reports of its Fellows, we could not afford the nominal subscription price of $5.00 domestic, and $5.50 foreign mailing. This is half the price of the only comparable publication—the Journal of the Textile Institute, which with membership and to non-members is Two Guineas ($10 approx.). This publication also carries paid advertising. Were we to make our subscription price the same as the dues of annual members it would more accurately reflect the cost of the service thus rendered, and would also add to our annual class of membership all who are actually receiving the major part of the services for which that class qualifies.

U. S. Institute for Textile Research is deeply indebted to the Textile Foundation for co-operation that makes possible the publication of the magazine. U. S. Institute is also indebted to those members of the Board of Editors, the Publications Committee and the Committee on Abstracts who contribute their services. It is also indebted to the increased number of those who have made use of the magazine for the publication of original researches. Your managing editor regrets that lack of publication funds and space so often delays the printing of the latter type of contributions.

The Book, "Textile Research: A Survey of Progress"

Sales of our book reviewing textile research progress up to 1932 have not been active for more than a year, and your Executive Committee has authorized the Research Council to proceed with the compilation of a new book reviewing progress during the last five years. Largely as a result of an offer of free copies to libraries in textile cities and towns 67 copies were distributed during the fiscal year. Of an original printing of 2,574 copies we have distributed 2,191 copies, and have an unsold stock of 675 copies. A mutually satisfactory arrangement has been completed with Massachusetts Institute of Technology by which U. S. Institute has paid the $1,000 which the former advanced against publication cost of the book. The settlement of the M. I. T. account was made possible by assigning to that institution the laboratory and certain equipment for the warp sizing study at M. I. T. for which approximately $1,000 had been paid from the warp sizing fund. This arrangement leaves the book account with a bookkeeping cash balance as of Oct. 30, of $226.24.

The experience gained in the compilation, printing and marketing of the first book should be invaluable in planning for its successor. The former's cash sales of 1,028 copies should prove the minimum basis of sales of the new book.

Financing of Textile Drying Project

A large part of your Secretary's time since the conference on textile drying, held in May, has been devoted to securing 50 subscribers and an initial fund of $5,000 for this project. As previously noted, 25 subscribers have been secured thus far, and at least a half-dozen more are "good prospects." While the canvass is twice as far advanced as was the warp sizing financing for the same period we have twice the number to sign up. Furthermore, 10 of the contributors were previously either regular contributing members or subscribers to the warp sizing fund. The revised and expanded research program, to be presented today by the committee for this study, should broaden interest and win more general co-operation in the financing. Members can aid this work by giving as wide publicity as possible to the fact that, until Jan. 1, 1937, new contributing members will qualify to receive during the fiscal year confidential progress reports of both the drying and warp sizing studies. The research program and the list of co-operators to date in the drying study may be obtained from the Secretary.

The Warp Sizing Project

My routine activities in connection with the warp sizing project have been the renewal of co-operators for the second year, and the preparation and mailing of confidential progress reports. All co-operators were renewed excepting two—one who came in originally for only one year and one who discontinued business. To make good these losses your Directors authorized transfer to the list of co-operators of two contributing members who came in specifically for the reports of this study.

Four confidential progress reports have been mailed to co-operators, and to contributing members who have requested them, and a fifth report is now ready for mimeographing and mailing, the latter being the second report on the viscose-process rayon phase of the study.

Necrology

It is with regret that we must report that, during the fiscal year, death has taken from us the following members:

Name	*Membership*
Mr. Joseph Bancroft	Original annual
Mr. Albert F. Bemis	Original annual
Mr. George L. Gilmore	Original annual
Mr. E. E. Boreham	Contributing
Mr. Claxton Monro	Annual
Mr. Robert N. Gee	Annual
Mr. J. Foster Smith	Annual

The Research Conference

THE conference which convened in the Jansen Suite at 2 P.M. was sponsored by the Research Council, and in the absence of Chairman Emley was presided over by Vice-chairman Smith. An audience of approximately 100 was in attendance, and although such uncorrelated subjects as textile drying and cellulose chemistry were presented and discussed the interest of those present was maintained until adjournment, and even thereafter the principal speakers, Mrs. Farr and Mr. Ross, graciously continued for some time to answer questions.

Because the Committee on Drying (W. E. Emley, Chm., Alban Eavenson and Dr. H. DeW. Smith) had been successful in prevailing upon John O. Ross, president of Ross Engineering Corp., New York, N. Y., to prepare a paper on "Some Drying Problems in Other Industries Than the Textile Industry", the scheduled program was not followed and he was presented as the first speaker. His paper, which will be found on another page, was followed by an animated and interesting discussion, which demonstrated that in other industries than textiles may be found certain drying procedure that can be applied to advantage by textile manufacturers. Of particular interest were the high drying temperatures reported by Mr. Ross as prevailing in the paper and other industries, and that are claimed to have no damaging affect when the moisture content of the dryed material is adequate; the pre-heating and heat recovery methods that he explained were also of much interest. Limited space in this issue prevents publication of the discussion that followed the papers by Mr. Ross and Mrs. Farr, but outline reports of these will be made available to members of U. S. Institute on request to the Secretary.

There was no formal discussion of the second subject on the program: "Textile Drying in Its Connection with Chemical Processing." It was, however, the subject of inquiry and discussion in connection with Mr. Ross' paper, particularly that part of the paper related to the drying of coated and colored papers.

Drying Research Program

Following the discussion of Mr. Ross' paper Vice-chairman Smith presented and explained the revised and expanded program for the textile drying project, as follows:

> "Purpose: To ascertain some of the fundamental facts underlying the design of drying equipment for textiles. To develop information about the way textiles can be dried with maximum efficiency and minimum injury to the material. To assist in applying this information in individual plants.
>
> "Problems: (*a*) Regain. Samples of each of the textile fibres, as nearly pure as can be obtained, will be analyzed to ascertain their purity for the record. They will be dried or humidified in a laboratory oven, in which the temperature, humidity, and circulation can be closely controlled. The amounts of regain (both adsorption and desorption) will be determined at all temperatures from

> slightly below room temperature (150° C) to as high as the fibre will stand (perhaps 300° C in some cases)."

It was the sense of the Committee, as a result of the May conference, that the one thing nobody knew much about was the moisture regain of textile fibres at higher temperatures. We all have accurate curves that have been made in laboratories in this country and abroad of the adsorption and desorption isotherms of all of the fibres that we use at room temperatures, and we believe you expressed the wish that that data should be extended throughout the range of temperatures that we meet in drying; that there should be a group of charts, a group of fundamental data that any one of you could use in determining what drying conditions of dry and wet bulb you must have to maintain a certain moisture content in your fibre. And that is the first thing we propose to do, as quickly as we can.

> "(b) Effect of Regain. Samples of each fibre containing widely different amounts of water will be studied to establish a criterion for measuring the difference between them. This may be found to be a difference in chemical composition, in tensile strength, in flexibility, in ability to absorb dyes, or in some other property."

It was the sense of the Committee that that was the second great need that you people expressed, namely, how hot can a fibre be, or how dry can it be at a given temperature without damaging it, and what kind of damage will make itself evident? That is much more complex than the first, but we believe, based on the first, it is the next thing to work at and that it can be accomplished as a laboratory research problem.

> "(*c*) Effect of Machine Variables. Certain factors encountered in commercial dryers will affect the rate at which equilibrium is reached and the properties of the dried fabric. The laboratory oven will be used to study the effects of such factors as speed of circulation of air, sudden increases of temperature, drying in contact with metal, intermittent drying, etc."
>
> "(*d*) Effect of Impurities. Textile fibres are seldom used in the pure state. The laboratory oven will be used to study the effects of additions of starch or gelatin sizing materials, dyestuffs, finishing materials, variations of pH, etc."

The method by which we plan to undertake this work is as follows: "A Ph.D. physicist will be employed and given laboratory facilities to start work on problem (*a*)." This is the question of determining the regain or the moisture content of fibres under different wet and dry bulb temperatures over the higher temperature ranges. "By the end of the first year, he should have problems (*a*) and (*b*) completed." I believe in the first proposal we sent out, it included a one-year plan. We have lengthened this to two years, because we believe that the problem will warrant two years and that it will take two years, and that the second year will be much more useful to you than if we were to plan now to cut the work off at the end of the first year and turn it over to you. "At the beginning of the second year, this information will be ready for application in individual mills. Any mill desiring to take advantage of the opportunity will

be expected to furnish its own equipment and personnel, the physicist acting merely in an advisory capacity, with trips to the mill as required. At other times he will continue his laboratory work on problems (*c*) and (*d*)."

In other words, we propose to provide a consulting service to you. If we can get this information which you want, then we propose to make it available to any of you who wish to use it, and the man will be able to go to your mill and work with your people in applying the information which we hope to gather on the regain of these fibres under various conditions, and on the effect of that regain on the physical and chemical properties of the fibre.

> "Cost: One man plus equipment, supplies and travel, at a total of $5,000 a year for two years. This is based upon the assumption that the work will be set up at some place where the necessary space, light, heat and usual equipment will be furnished gratis, where the work can be properly supervised, and where men experienced in drying problems can be called on for advice."

That in brief is the program as we have outlined it and we welcome today your criticism, in an effort to make the thing bear fruit as rapidly as it can. I would like comments on this. Is there some phase of this drying problem that you think is more important than these things we have outlined, or do you think we have not outlined them correctly?

We have worked over the entire record of the May 6th meeting and tried to base this program on the opinions then expressed, but you have all had six months to think about it, and we have been thinking about it a good deal ourselves. We would be very grateful for additional suggestions from you that will round this thing out and make it more useful to the industry, because although we have received to date 25 promises of contributions to this research I believe most of these promises were made on the basis of the one-year plan. Several of the concerns who were represented at the conference in May came in immediately and said they would co-operate with us. I think most of them know by now that we have extended this to two years, and if we start it for one year we are going to count on their support for the two years. But the fact that these 25 firms are interested shows that information is wanted, and we do want to make the program successful and make it meet your needs.

Discussion

Chm. Smith: Dr. Quig, are you going to help me out?

Dr. Quig: I think the program that you have set up is adequate enough, certainly for the time being, and I shall just comment on one or two of the divisions. So far as I know, regain data is not available. I have been asked for it a number of times. The textile industry wants this information on regain, both adsorption and desorption, at the various temperatures.

I am particularly interested in "(*d*)" which is the effect of impurities, because I believe that what we might call the residuals that are found in the fibres have a most vital effect on what we are going to get in drying.

I am very much interested in dyestuffs also. It has been our experience that certain colors are susceptible to giving blotches and residuals in the fabric. Probably the dyestuff people know the answer to that. But in rayons, particularly in acetates, where we are dealing with residuals of

gelatin and sulfonated oils, for example, we find that a certain green is very susceptible to this blotchiness. We speak of it very loosely. We say that maybe some of the dyes formed lakes during the drying, whereas it may be a concentration of the oils or of residual gelatins.

The only fear that I have about the program is the setting it up on a two-year basis. Having had contact with the warp sizing research, I think the program is plenty ambitious, but no doubt if it is a success you will have no trouble in extending it.

Chm. Smith: That is perfectly true. When we say a two-year program, perhaps we ought to qualify it by saying that we cannot promise to deliver the complete goods in one year or in two years. We have found that the warp sizing study may call for a continuous program, since there are changes and progress in materials and in machines going on all the time. If we can produce in two years sufficient data to demonstrate the value of such work then we should have no difficulty in continuing it, and we hope that since the initial problems of this drying research are very definite, we can produce practical, useful information for you more quickly than we have been able to in the case of warp sizing, which is a much broader study and much more difficult to grasp at any one point.

If you have followed the reports of the Warp Sizing Committee as to the plan of operation, I believe you will see that it has evolved into a practical program; and I happen to know, because I am privileged to see these confidential reports as my company is a contributor, that it has reached the stage where it is producing information that any intelligent mill can take and make use of to an extent far exceeding $100 a year.

The problem that we are going to be up against with these researches is to finance them and to finance their continuation, and I think the simplest argument is that for $100 a year no firm could get even the photomicrographs that they will get in these reports, nor even one very small phase of the data which they get. That is an appeal for money. That concerns us very much. We have to work out a method of keeping the financing of these problems going. They can only go as far as there is information that you people want. But it is true that unless they go long enough there will be no information that you want, and that there will be a point reached when the thing will be obvious and clear to everybody—the value that lies in it. But until we reach that point they certainly merit support and I believe will render value for the actual money put in, even in the early stages of these various projects.

We would appreciate it if you would read this program carefully and let us have your suggestions and comments by mail, because we want to shape it up as soon as possible and start work. Your Committee is a small one. The Research Council is a small one, composed of men who are vitally interested in this work and they need and will appreciate your co-operation.

Mr. Hawkins: Dr. Smith, I would like to emphasize Dr. Quig's request for a study of the regain of various fibres. In other words, at 65% relative humidity cotton has one regain, acetate has another value, rayon another value, and wool has still another value. Why is it that these fibres do have different moisture contents? Is it in the fibre? Is it on the surface, or where is it? I think the other big variable would be the design of the machine. From the studies that we have been conducting for over a year and a half now, the impurities in the goods do not affect the moisture very much. Of course, our experience is limited to cotton and rayon, and only

in a few mills. But I have found a tremendous difference in machines, primarily in the way the soap plus moisture is extracted before it is sent to the drying cans, or the drying chamber. I think the concerns manufacturing machinery have a tremendous field for improving their machines so as to deliver the goods to the drying chamber or drying cans with uniform moisture in it. I should like to hear the comments of the machinery builders on that point.

Chm. Smith: Are there any comments on that? I don't know anything about it, but I should think that would be a very reasonable premise—that delivering the goods to the machine with uniform moisture content would be wise, and that a minimum moisture content is certainly economical I can give you a personal experience on the problem of whether you can put anything on the yarn that will essentially alter its regain, because some of my earliest efforts when I got out of college were in trying to coat yarn with an oil, or something that would reduce the regain, and we never found anything. These films on the fibres don't seem to do anything except possibly slow up the rate at which the equilibrium sets in, unless they are hygroscopic materials, in which case of course they add their effect. And, from our experience, highly hygroscopic material will take moisture out of the yarn as well as out of the air, so it doesn't always do what you think it is going to do.

I think that we have explored this very dry subject long enough and if you have other comments I hope you will mail them to us.

Dr. Farr's Paper

Dr. Smith then introduced the last speaker, Dr. Wanda K. Farr of Boyce Thompson Institute for Plant Research, stating: "I take particular pleasure in introducing Mrs. Farr to this group because, as far as I know, it is the first time that she has presented her work to a strictly textile group. I happen to have been privileged, from the days when she was cutting cotton bolls in half and examining their structure at various stages of growth, to follow the work that she has been doing. I have gotton a growing sense of the importance of that work in cellulose research and in textile chemistry as it applies to cellulose fibres both natural and artificial. Many of you probably are thoroughly familiar with it. I doubt very much whether all of you, even if you have read her papers or seen her work, have perhaps fully appreciated what a fundamental effect it may have on our conception of the structure of cellulosic materials and on their behavior as textile materials, not only their physical behavior but also their chemical behavior towards dyes, towards chemicals, their regain, etc. I believe that nothing could be of more interest to the cellulose end of the textile industry than will be provided by a careful consideration of the findings which Dr. Farr has made and which she is going to present to us now under the title of 'A New Viewpoint in the Study of Cellulosic Textile Fibres.'"

An outline of Dr. Farr's remarks will be found on another page. Actually, she spoke without notes and her talk was illustrated by a large number of lantern slides, the absence of which robs her remarks of much of their clarity and interest. She was roundly applauded when she finished and was then subjected to somewhat protracted questioning which she answered extemporaneously and freely. The meeting then extended a unanimous vote of thanks to Dr. Farr and Mr. Ross and adjourned at 4:30 P.M.

Some Drying Problems in Other Industries Than the Textile Industry

By JOHN O. ROSS *

THE purpose of this paper is to present to the textile industry some of the drying conditions and processes that are being attempted in other industries, in order to simplify or make more economical the use of dryers and also to improve the quality of the products that are being dried. It is very likely that many of these processes will not be of value to the textile industry and that even the ones that do have merit may have to be changed to conform to different requirements of the textile industry. It may be however that some of these things will plant a thought that may be worth further investigation or adoption.

In the first place, it is assumed that the business of a textile manufacturing company is primarily the production of textiles that can be sold profitably, and not the development of dryers which may be exceedingly efficient and be wonderful in every way, unless these same dryers are the means towards the production of such textiles.

Drying Methods in Coated Paper Industry

The coated paper industry employs generally the principle of coating the surface of the raw paper sheet with material which may change the color of the sheet, or may prepare the sheet for printing, or may waterproof or decorate the paper. There are several new trends in dying methods in the coated paper industry. The first is that serious progress has been made in reducing the water content of the coating mixture. It has been apparent that the dry material contained in a coating mixture is the material that stays on the paper, and that the water content contained in that mixture when it is applied to the paper is the drying load. If less water content is present in the mixture, less work has to be done by the dryer, which means not only a reduction in the heat required, but less space required as the paper will dry faster.

Today it is safe to state that almost every coated paper plant uses coating mixtures containing much less water than they did previously. The old-time mill operator looked with considerable disfavor on this tendency, and it was true that this transferred the problem partly to the coating machines themselves. In other words, radical changes had to be made in the coating machines in order that a coating mixture containing much less water could be applied properly to the paper. In many cases it also meant a different choice of ingredients in the coating mixtures. Materials which required a great deal of water had to be eliminated and replaced by other materials that would secure equally good or better results and required less water content. Progress has by no means ceased along those lines, but great advances have been made. The time required for drying the paper has been much reduced; machines can be speeded up, and in many cases the paper can be dried in a straight line without having to be looped into festoons, which festoons caused other problems in the finishing.

The next development in the coated paper industry was the selection of different coatings, leading to the lacquers and similar quick-drying

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materials. It has been found that many papers coated with lacquer coatings were even better for the purpose and dried infinitely faster than the older coatings. This again has caused a change in design of coating machines to properly apply these quick-drying materials.

Another development is the use of much wider coating machines. Indeed, the development of the coating machine is towards coating a sheet of paper as wide as it comes from the paper machine itself, so that today coating machines over 100 inches wide are not uncommon.

They have even gone so far as to select coating materials that can be applied directly on the paper machine in one operation, instead of doing it in steps. There are three mills that are today coating directly on the paper machine while the paper is partly dry. In other words, they apply an almost dry material onto a partly wet sheet and save the expense of drying out the sheet completely and then wetting it again.

Drying in the Paper Pulp Industry

In the raw stock paper and pulp industry, where the drying problem is also a very expensive part of manufacturing costs, great progress has been made in removing the water mechanically as far as possible before it enters the dryer. Improved press rolls, suction methods of removing the water, and similar means have been used at the making end of the machine so as to deliver to the dryer a sheet as dry as possible. A few years ago a wet sheet of paper entering the dryer which contained 25% dry material and 75% water was more the rule than the exception. Today, it is more apt to be 40% dry material and 60% water and, in some classes of paper, and in the pulp drying industry it has reached 55% dry material and 45% water. It does not take very much figuring to see how greatly the drying load has been reduced by those means. In other words, the drying problem has been reduced to less than half of what it was.

Another development has been the study of how much moisture can and should be left in the paper after leaving the dryer. It has been found not only possible to leave more water in the finished sheet, but it has also been found that the customers prefer it. They not only are willing to pay paper prices for water, but are beginning to insist upon it. This, of course, cannot be carried too far because excess moisture makes the problem of finishing the surface of the paper more difficult; but the proper amount of moisture makes the finishing process easier. Uniform drying has also engaged a great deal of study. If the sheet of paper is not uniform in moisture content throughout its entire width it means that a great portion of the sheet must be dried more than necessary in order that the wettest portion may be reduced to the proper content. Therefore, the average water left in has been much increased. As this removal of water comes at the dry end of the process, where it is the hardest to remove and the slowest, there has been considerable improvement in the cost of drying. What this emphasizes is that it is useless, or at least inadvisable, to try and produce the most efficient dryer for the purpose unless it has first been proved that every effort has been made to reduce the amount of work which the dryer has to do. That is why it is so difficult for a dryer man to solve the whole problem. He should not simply have a certain job turned over to him to be solved by his dryer, because with proper study of the process itself his problem may be greatly simplified.

Preheating and Heat Zoning

In many industries heating up the goods and the water contained in the goods has been given consideration. How many dryers have you seen where the goods were half way through the dryer before they were heated up enough to do any drying? Yet preheating the material, either before it enters the dryer or immediately after it enters the dryer, may be done in a much less expensive mechanism than the dryer itself and may be done much more economically than the dryer is able to accomplish it.

This leads to two general thoughts: (1) Some of the chemical industries use a very much higher temperature in one zone of the dryer than in the other. In other words, many materials which will not stand a high temperature when they are partially or nearly dry will stand a very much higher temperature when they are wet. Temperatures as high as 1000° have been used in preheating certain materials and yet the drying process itslf is conducted at a temperature of only a fraction of that heat. With the modern methods available for circulating air, it is quite possible to have any number of zones in the continuous dryer at any temperature and humidity desired. A careful study of the material being dried to determine the best available temperatures, not as an average but at various points in the drying cycle, is well worthwhile.

(2) Everything else being equal, the higher the temperature employed, the more economical is the drying. It should, of course, be borne in mind that the mill owner is not interested in efficiency of drying if it is at a sacrifice of the quality of the goods. At the same time many materials will stand much higher temperatures than are being used, especially at a certain part of the drying cycle. Temperatures have generally been limited to temperatures of steam. There are, of course, oil circulating systems circulating oil at high temperatures, but many industries find that their practical limitation is their steam temperature.

Direct and Indirect Heating Systems

In one industry in the automobile accessory line temperatures of 400° were used and special boilers for 500 lbs. steam pressure were installed. Yet the 400° was not the maximum desirable, but it was simply the highest temperature that could be secured with reasonable expenditures for boilers and piping. This industry today is using air heated by direct-fired oil and gas burners and this development of heating air by these heaters has revolutionized the drying of many materials.

These heaters fall into two classes: the direct heater where the products of combustion are mixed with the circulated air, and the indirect system where the products of combustion pass through a heat interchanger which heats the air by transmitting the heat through the walls of the interchanger. Temperatures of 600° are commonly encountered; 800° is readily available; and even 1000° is used.

In the textile industry it would probably be true that it would not be advisable to use the direct type of heater, but that the indirect type of heater should be used. These heaters are so built that they are automatically regulated to hold the temperature of the air within one or two degrees. They do not shut on and off, as in the ordinary household, oil burner, because the varying range in temperatures is too great. These

heaters may be used, of course, for moderate temperatures of air easily reached by steam, but they offer many valuable opportunities either for boosting temperatures in certain zones of a dryer or for the entire dryer, and for carrying temperatures beyond anything easily reached by steam. The drying medium, either pure air, or air mixed with products of combustion, may be recirculated in any proportion, just as in a steam heated dryer.

These heaters are well adapted for dryers using volatiles which are inflammable. These volatiles are explosive within certain ranges. The drying temperatures must be kept either above the explosive range or below the explosive range. Generally, we favor carrying them below the explosive range due to the danger of leaks causing explosions. These fumes in themselves present a problem for disposal. In some industries solvent recovery systems are installed partly to dispose of these dangerous fumes, and partly to recover the solvent. In dryers equipped with the oil-fired heaters already mentioned, some progress has been made in bringing these fumes back through the oil burner and burning them. This not only solves the problem of disposing of them, but the heat to be recovered by burning the fumes is a very considerable proportion of the drying load. This often opens the way to using lacquers and similar products with a comparatively cheap and highly efficient method of disposing of the fumes. Many dryers which have reached their ultimate capacity under steam can be greatly increased by the addition of superheated air. In new plants these heaters will often do away with the necessity of high pressure boilers, and in old plants may mean an increase in the drying capacity or heating capacity without adding to the boiler plant.

In the can industry, where paper labels on the cans are being gradually eliminated by the use of printing directly on the can itself, the problem of printing on a round can was solved by the process of printing on the flat tin before it was made into the can, and the tin in flat sheets was very much more easily handled and dried than the finished round can would have been. Without this change in the process of making cans, the drying problem would have been to handle and dry not only the outside but the inside of millions of cans, and it would have been an enormous drying problem. By changing the process the problem was very much simplified. That illustrates what I mean when I say that a drying problem isn't necessarily just the way it is handed to you. You may have to go back in the mill and make your problem very much easier.

Heat Recovery

Another field that the paper industry has gone into is the recovery of waste heat in the vapor laden air from the dryers. Outside of radiation and the heating up of the goods and the contained water, all the heat supplied to the dryer is carried away in the vapor laden air. On paper machines this is an extremely large quantity, and yet great quantities of fresh air used to be brought in and heated by steam or other means, while today, by the use of interchangers, the heat in the outgoing vapor laden air is used to heat the incoming fresh air with tremendous savings in steam. The vapor laden air from a paper machine dryer is at a comparatively low temperature, usually not over 120° F., so that it would not seem to offer the possibilities for heat recovery that would be accomplished in ordinary dryers. However, the quantity of fresh air used for this com-

paratively low temperature is very large and, in addition, the paper mill runs twenty-four hours a day and requires this heating about 300 days a year, so that the return on the investment is very high. The paper machine dryer is practically a room heating and ventilating problem, but in the textile mills, running a much shorter number of hours a year, it would probably not pay to use this heat recovery for heating the mill buildings themselves because the heating season is much shorter than the ventilating requirements of 300 days a year in the paper mills. The southern mills particularly would not find it at all efficient. However, on the textile dryers themselves, although they do not run 24 hours as a general rule, they do or should run most days in the year, and the temperature of the outgoing vapor is so high and the quantity so comparatively small that the cost of recovering this heat should be worthwhile; especially when high temperatures are used, the vapor laden air is so small in quantity and contains so many grains of moisture with a high dewpoint that the recovery of this source of waste may be worth consideration.

High-Pressure, Hot-Water Heating

One last process that I will mention is the development of high-pressure hot water. This has been done to a very slight extent in this country, but has been developed to a far greater extent in Europe. Our company is engaged in developing this in this country, having taken over rights and accumulated experience of European processes. Briefly, it involves taking hot water from the boilers instead of steam and circulating it at boiler pressures, which means at the same temperature as the steam, so that anything that can be heated by the high-pressure steam can be heated to the same temperature by the hot water. It offers many advantages. First, there are no traps. All water is returned to the boiler and the only loss that occurs is the radiation and the work actually done. Return lines can be brought back regardless of the grades. There is practically no make-up water required in the boilers, and I do not need to say what that means in deterioration and cleanliness of the boilers and piping. In addition to this, as the water temperatures may be varied at will, it means that uniform temperatures may be secured throughout dryers even when the heat load is greatly changed. It is well known that if steam is throttled down a smaller quantity of steam may not reach the extreme end of the coils, while with hot water the same quantity of water is circulated but the temperature is changed. This is perhaps one of the reasons why this process has first been most acceptable to manufacturers of bakelite and similar processes using heated presses. They get an absolutely uniform temperature across the entire face of the press. Also as the volume of water can be increased very rapidly, it means that the heating up time may be greatly reduced.

In some industries where this process is being used it is a common practice to have large tanks of water, sometimes containing certain ingredients, and these tanks had to be heated by steam coils in the water. Considerable difficulty was encountered in getting out the condensate from those coils and often the steam pipes bled directly into the water. This not only meant an enormous amount of make-up water on the boilers, but also diluted the mixture in the tanks so that changes in color or viscosity would occur between the time the water in the tanks was cold and when it

was heated up. With this high-pressure hot water there is no difficulty in bringing back the returns so that closed coil systems may be used. As the entire system is full of hot water, a great reservoir of heat is available for use in starting up in the morning so that more uniform conditions in the boiler plant occur. I am, of course, speaking in a brief manner as to the possibilities of this type of system.

I have tried generally to cover in this paper some of the things that are being done in other industries. Undoubtedly, many or most of these have been considered in the textile industry but a re-examination of them may be worthwhile. Before making an intensive study of the efficiency of various competing dryers, an effort should be made to see whether or not the drying problem itself can be simplified and made easier. We should also make sure whether or not it is possible to use different materials or materials that are easier to dry. There should also be a study as to the most economical temperatures, and this study should be extended through the entire drying cycle, always bearing in mind that a temperature which injures the goods is not an economical temperature, no matter what the dryer man says about it.

A New Viewpoint in the Study of Cellulosic Textile Fibres

By WANDA K. FARR *

CELLULOSE, in the form of small uniform sized ellipsoid particles, has been identified in the living cytoplasm of young plant cells which are forming cellulose membranes. These structures have been observed by botanists for the past century and have been designated by various investigators as "granules," "particles," "microsomes," and "dermatosomes." Before 1850 Valentin had observed their behavior in building up the cell wall. Other contemporary investigators identified them chemically as protein because they stained yellow with iodine. These fragmentary and scattered observations have a new significance in the light of a more comprehensive study of the *cellulose particle* from its first appearance in the living cell to the time of its final location as a permanent structural unit of the plant cell wall.

Cellulose particles are very numerous in young cotton fibres and may be readily removed from the living cytoplasm for more specific study. Many of their properties are then more readily discernable. They are ellipsoid in shape with a major axis of about six one-hundred-thousandths of an inch. They stain brightly with ruthenium red and are weakly doubly refractive in polarized light. When treated with a weak solution of either acid or alkali and washed with water, they no longer stain with ruthenium red and are much more clearly doubly refractive. Evidently a surface coating which had lowered the brightness in polarized light and had reacted to the stain was removed by this treatment. The refractive indices of the washed particles, their reaction to sulphuric acid and iodine, and their X-ray diffraction pattern all confirm their cellulose nature. These particles from the living cell show, therefore, all of the characteristic reactions of cellulose and are surrounded by a thin coating of material

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which reacts positively to none of these tests. This substance which covers the surface of the particle plays the important part of a cement which holds together the particles in the process of cell wall formation.

As the development of the cotton fibre continues the particles are formed in the outer part of the cytoplasm arranged end to end in a single strand. Finally, the identity of the particles in the chain becomes less and less distinct in the formation of the single fibril of the cotton fibre wall. These fibrils are ultimately arranged spirally in the lamellae which constitute the mature membrane.

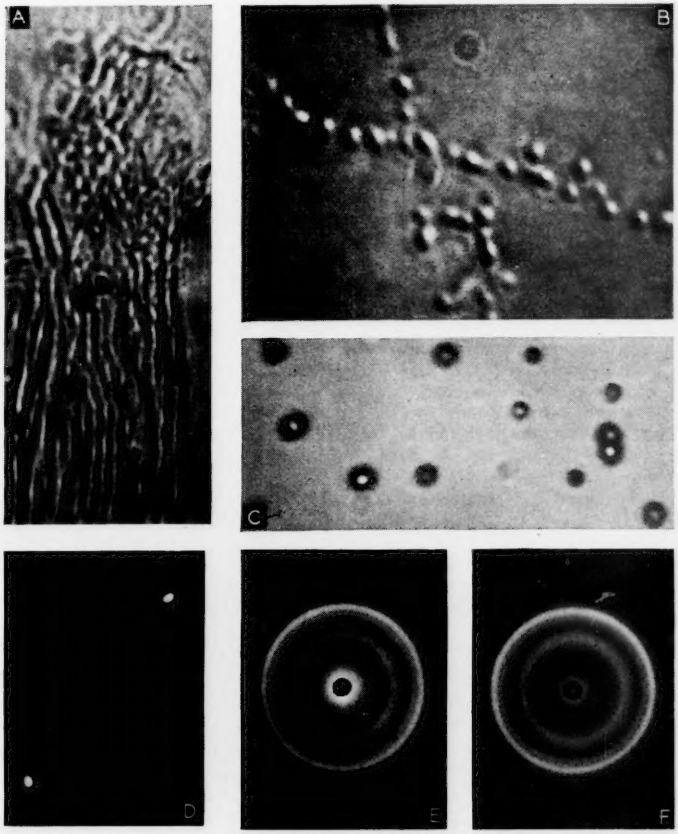
The membrane of the mature cotton fibre is therefore a very intricate structure of ellipsoid *cellulose particles* held end to end to form a fibril and the fibrils, in turn, to form the lamellae by a *cementing material* which surrounds them. The fibrils in the mature membrane may be separated by treatment with solvents for the cementing material. Longer treatment with the same solvents brings about the breakdown of the fibril into its constituent particles.

The cementing material, which constitutes not more than three or four per cent of the entire fibre mass, may be extracted with either weak acids or alkalies. One of its constituents is undoubtedly pectic acid. Its exact proportion and the nature of the associated constituents are not yet determined. These treatments bring about a very slow disintegration of the fibre and have their chief value in the recovery of some of the constituents of the cementing material by precipitation from the filtrate with alcohol.

Much more rapid membrane disintegration is brought about by treatment with strong HCl (sp. gr. 1.19) or HCl gas. The fibre wall is broken down first into larger and then into smaller membrane fragments, each of which may be resolved into its constituent particles by slight mechanical treatment. In all of these instances we are dealing with membrane disintegration and not cellulose degradation. The properties of the particles themselves are not different from those which are taken from the living cytoplasm.

It has long been known from both microscopic and X-ray diffraction analyses that the fibres are definitely crystalline. According to Nägeli's hypothesis, upon which our interpretations of cellulose reactions have been based for the past seventy-five years, the membrane is made up entirely of submicroscopic crystalline micellae. This conception has not adequately accounted for the many colloidal reactions of the membrane. It is of interest to note, however, that fundamentally there is a strict agreement between the original micellar hypothesis and our observations of cellulose membrane. Nägeli postulated the presence of submicroscopic crystallites in orderly arrangement; we see the crystalline cellulose particles in orderly arrangement. Nägeli placed the membranes in water and considered the swelling to be due to the entrance of the water between the micellae; we observe in the moistened fibres the swelling of the protective colloidal material and the consequent pushing apart of the particles. It is therefore not necessary to account for both the colloidal and crystalline properties of the cellulose membrane upon the basis of the reactions of a single organic chemical. The cellulose particles will account for the crystalline behavior and the cementing material for the colloidal behavior. In a fibre reaction we are dealing, therefore, not alone with cellulose but with a plant cell membrane of both physical and chemical complexity. Paradoxical as it may seem, the recognition of this complexity greatly simplifies our outlook for the future in fibre research.

The separated membrane constituents offer new experimental possibilities in well established fields of "cellulose" analysis. In the first place we must have as complete a chemical and physical analysis of both the cellulose particles and the cementing material as it is possible to make.



A.—Fibrils and particles in cellulose membrane of cotton fibre treated with a solvent for the cementing material (enlarged to 2400 diameters)
B.—Separated cellulose particles from membrane of mature cotton fibre (enlarged to 3000 diameters)
C.—Sulphuric acid-iodine reaction of individual particles (× 1380)
D.—Separated particles in polarized light enlarged to 2800 diameters
E.—X-Ray diffraction pattern of ground cellulose fibres
F.—X-Ray diffraction pattern of isolated cellulose particles

This will involve organic chemical, colloid chemical, X-ray diffraction, microscopic and combustion analyses, along with the more complicated reactions of the separated constituents to bacteria and enzymes.

We know already that the cellulose particles are doubly refractive, and their refractive indices are 1.565 lengthwise and 1.530 crosswise; that their X-ray diffraction pattern is that long known to be typical of cellulose; that their combustion analyses show approximately six parts of carbon, 10 parts of hydrogen, and five parts of oxygen; that their size and shape are remarkably uniform throughout the entire plant kingdom; and that they are not easily destroyed. Many of the fibre reactions which have been designated in the past as cellulose degradation represent only membrane disintegration. The cellulose particles themselves remain apparently unharmed, in the form of a white powdery residue.

The fractions of cementing material which may be extracted with weak solvents have already been subjected to uronic acid analyses and the results establish definitely the pectic nature of one of the constituents. More careful analysis of more highly purified samples of ammonium oxalate extracts give a higher percentage of pectic acid. It must be emphasized that this represents only one of the constituents of the cementing material, the most obvious one which we have determined first. One of the most difficult problems with which we are dealing is the separation, without loss, of this cementing material and the differentiation of its various components.

Into the field of cellulose derivatives we are carrying our research through a study of the reactions of the separated membrane constituents to acetylation, nitration, xanthation, and treatment with cuprammonium hydroxide. The study of the behavior in cuprammonium hydroxide of untreated cotton, cellulose particles from cotton, and separated cementing material is now well underway.

The separated cellulose particles, when freed from the cementing material, will not produce viscosities in cuprammonium hydroxide. In the residues of fibres extracted for different lengths of time with solvents for the cementing materials, the viscosities decrease as the time of extraction increases. Viscosities are produced, however, with the fractions of the cementing material which we extract. These data indicate that the cellulose component of the fibre membrane does not dissolve to produce the viscosities which are commonly attributed to it, but that these viscosities are produced by a reaction between the cuprammonium hydroxide and the cementing material, the particles themselves being in a state of dispersion.

A microscopic examination of the mixtures of cotton and cuprammonium hydroxide corroborates this chemical behavior. The particles are seen to be dispersed throughout the mixture. When removed from the viscous matrix they are still doubly refractive and react in their characteristic fashion to sulphuric acid and iodine.

When a single fibre is treated with cuprammonium hydroxide, the outer limiting membrane does not dissolve. The rapidly swelling inner layers of the membrane burst through this resistant covering in a series of balloon-like enlargements. The cellulose particles are not visible at this point in the reaction. If, however, the swollen fibre is carefully washed with either cuprammonium or ammonia alone, it becomes evident that the presence of the particles has been obscured by the swollen cementing material. Even the double refraction of the mass of particles in the fibre is masked by the swollen cementing material. This reaction, too, may be carried past the point of disappearance in polarized light by

washing the treated fibre with more of the cuprammonium. The double refraction of the cellulose portion of the fibre then reappears.

Additional Studies and Problems

There are several other studies now under way which we shall have time only to mention: a careful analysis of the effect of mercerization; a more comprehensive survey of cellulose membranes throughout the entire plant kingdom; a study of the formation and structure of lignified membranes; and last, but perhaps first in importance, a search for the origin of the cellulose particle itself in the cytoplasm of the living cell.

Among the many problems which we hope some day to study in detail are those of the hygroscopic behavior of fibres and their reactions to dyes. From scattered observations we have the impression that the hygroscopic behavior of the fibre is primarily associated with the reactions of the cementing material to moisture, augmented by the fact that upon softening this material, the fibrils in the wall tend to straighten from their spiral position in the lamellae. We believe also that in the various processes of dyeing we shall be able to differentiate between the reactions of the separable membrane constituents. These impressions must be carefully checked and the measurable factors which enter into these reactions determined.

It is very clear, therefore, that the microscopic analysis of membrane structure and the separation of the primary membrane constituents, the cellulose particles and the cementing material, represent only a comparatively crude beginning of the detailed work which must follow. I wish particularly to point out that the sense of direction which this knowledge has given to us must not be confused with a feeling of assurance. A sense of direction may be put to some use in a laboratory, but that of assurance is fundamentally incompatible with any search for knowledge. Since, however, our work is largely observational, we are not immediately concerned with the more philosophic aspects of our activities. If we may succeed in properly evaluating our data and if through a correlation of these findings our reach, in the understanding of cellulosic materials, may sometimes exceed our grasp, we shall be pleased indeed.

The Annual Dinner

THE annual dinner was served at 7 P. M. in the Waldorf Astoria's Astor Gallery to 115 members and guests. The Jade Room was originally engaged for this function, but at the request of the Italian American Society, which gave a much larger dinner the same evening to the Italian Ambassador, the Jade Room was transferred to them, and this courtesy was made the logical basis of an amusing and instructive feature of the speaking program. President Garvan and several of the invited guests were in the reception line preceding the dinner, and as the speaking program was finished before 10:30 P. M., many members and guests had the opportunity for a social period thereafter.

Seated at the head table with Pres. Garvan were the following: Franklin W. Hobbs, Chairman, The Textile Foundation and President, Arlington Mills; Dean Joseph H. Willits and Dr. E. H. Killheffer, who were on the speaking program; Albert L. Scott, President, National Association of Finishers of Textile Fabrics; A. W. McCready, National Federation of

Textiles; and the following directors of U. S. Institute: Alban Eavenson, Dr. R. E. Rose, P. A. Johnson, Dr. H. DeW. Smith and F. S. Blanchard.

Among those who were present as guests of U. S. Institute were the following: Dr. Wanda K. Farr, Boyce Thompson Institute for Plant Research; E. T. Pickard, Sec., The Textile Foundation; and the following officers of associations co-operating with Dean Willits and U. S. Institute's Committee on Economic Research: W. P. Fickett, Pres., Textile Fabrics Association; Earl Constantine, Managing Director, National Association of Hosiery Manufacturers; A. F. Allison, Sec., International Association of Garment Manufacturers; H. R. Lhowe, Executive Secretary, National Knitted Outerwear Association.

Among the other leading manufacturers and merchants present the following were noted: Howard E. Coffin, Chm., Southeastern Cottons, Inc.; Harry L. Bailey, Wellington, Sears & Co.; Lincoln Baylies, Asst. Treas., Pequot Mills; Col. Millard D. Brown, Pres., Continental Mills; Leonard S. Little, Pres., U. S. Finishing Co.; F. R. Wheeler, Treas., Rossie Velvet Co.; R. G. Knowland, Gen. Mgr., Bigelow-Sanford Carpet Co.; Dr. F. Bonnet, The Viscose Co.; Dr. J. B. Quig, Dr. A. S. Hunter and Dr. J. S. Fonda, Rayon Division, E. I. du Pont de Nemours & Co.; A. F. Brown, Delaware Rayon Co.; Wright Bolton, Rayon Division, Pacific Mills; W. A. Broadfoot and H. C. Borghetty, Aspinook Co.

The Speaking Program

Hon. Francis P. Garvan, president of U. S. Institute and of the Chemical Foundation, acted as toastmaster at the annual dinner and his introductory remarks outlined briefly the objectives and results of two of the Chemical Foundation's most recent undertakings: The Cellulose Institute and the Farm Chemurgic Council.

Following his introductory remarks Toastmaster Garvan appropriately asked Chairman F. S. Blanchard of the Committee on Economic Research to introduce Dean Willits, the director of the "Survey of Production and Distribution Organization in the Textile Industry," noting that Dean Willits is one of the leaders in the field of economic research in this country, that he came to the Wharton School as an instructor in 1912, that during the world war he was personnel director of naval aircraft in Philadelphia, which plant was the only one that made deliveries on time during the war, that he then went back to the Wharton School and in 1921 founded its industrial research department, of which he is co-director, as well as dean of the Wharton School and executive director of the National Bureau of Economic Research. Mr. Blanchard also referred briefly to the work of his committee which led up to the placing of this economic study with the Wharton School, the details of which are contained in his report to the Research Council.

Following Dean Willits' address, which will be found on another page, the toastmaster stated that the Secretary had an announcement to make. The latter explained, as previously noted, why U. S. Institute was dining in the Astor Gallery instead of the Jade Room, and stated that the Italian American Society wished to extend formal thanks to U. S. Institute for this courtesy and had delegated one of their officers for this purpose, Capt. Angelo De Lucca, former Italian consul-general in Japan, and that he would also speak briefly of Japanese textile manufacturing and merchandising and the reasons why the Japanese are able to undersell the

manufacturers of all other countries. Captain De Lucca held the close attention of his hearers and when he closed his address the audience rose and applauded him heartily. While many of his statements were based upon actual facts, and tended to dramatize certain features of Dean Willits' address and the succeeding address of Dr. Killheffer, a question from the audience forced Capt. De Lucca to admit that he was merely an impersonator who had never seen Japan, and he then proceeded to speak of his adventures as a professional humorist. While the audience did not rise when this part of his address was completed, the liberal applause indicated that his impersonation had been taken in good part.

Dr. E. H. Killheffer, executive vice-president of U. S. Institute, who is associated with E. I. du Pont de Nemours & Co., was the last speaker, and his address, entitled "Why Textile Research?", was not only a convincing exposition of the need of research by the industry, but also a conclusive answer to those members of the industry who, for one reason or another, are refraining from supporting the co-operatively financed research projects that are made available by U. S. Institute. Dr. Killheffer's address is published complete in this issue.

Chemical Foundation Research

President Garvan's introductory remarks were in large part as follows: We have taken our first step to try to take the government out of the research business. We found some of the best people on cellulose research were not working under very happy conditions under the government and we have taken them out and established them in the Boyce Thompson Institute for Plant Research in Yonkers, N. Y., where they are making tremendous progress and I think we are all convinced of this from the speech of Mrs. Farr during the afternoon session. We are to be congratulated upon having attained that first step and I am sure that co-operating with you more intense progress will be made. Another branch of that institute has been established at Massachusetts Institute of Technology to develop cellulose chemists and to provide the university side of the research on cellulose. It is also supplemented by the working plant in Savannah, Ga., which has been working under Dr. Herty for the past five years. The progress there is beyond any dreams that we could have. Tonight I want to say that over $40,000,000 worth of paper mills are being constructed in the south which will use the slash pine made available by Dr. Herty's research. I went down to the opening of the Union Bag Mill. They are doubling their capacity. The president stated that the payroll of that new plant alone would be equal, by the time they had completed it, to the entire payroll of the city of Savannah before that plant was built. The kraft paper manufacturers and now the Scott Paper Co., and the Mead Paper Co., historically old established American paper concerns, have through the results of that research realized the possibilities of the southern pine, and with only one small partial loan from the government these nine concerns have gone down there and started a development the end of which will probably not be seen in our lifetime. We haven't yet begun on news print nor have we begun on rayon, though Dr. Herty's research lately produced 600 pounds of rayon pulp which was sent to the Viscose Co., and there run through to yarn and pronounced after a full examination as pulp equal or better than any they had ever used. Result, two or three pulp concerns are down there tonight examining the ground

to start the development for the use of the pine for making pulp for rayon. Thus the practical application of this great research progresses. All work together under Dr. Herty's direction, and you know Dr. Herty well enough to know that that also means full co-operation with all you gentlemen and your textile research institute. That is the way this subject of research grows. Not only do you get ahead yourself but you have begun to find co-operation from all directions; universities, institutions of research, trial plants and the industry itself. All begin to search around, sit down together and talk over and go ahead in the creation of new industries in this country.

Our other proposition is the Farm Chemurgic Council. It is growing just as fast as we can handle it. The soy bean was grown on six million acres this year. The farmers got a good price for it and the planting next year will probably be doubled. The government has appropriated $80,000 a year for a research institute at one of the western universities, and the paint manufacturers are co-operating, so that proposition is working out splendidly. It is said that we seem to have solved the successful use of hemp and flax, and the small plant which was built in Minnesota which had so much trouble for two years, now has funds and orders for fibres sufficient to keep them fully occupied for five years, which probably will necessitate the building of 10 to 15 new plants to be prepared for next year's crop. The sweet potato starch plant in the South is going on its third year. They will produce two million pounds of starch this year. The textile industry in the South is enthusiastic about it, and say it is the best starch they have ever used. An effort is being made to keep potatoes in storage for a longer time than heretofore and thus keep the plant running longer than two or three months. So far sweet potato used as starch has the greatest alcohol content of any farm product and it looks as if we would be able to raise more alcohol per acre in the deep South than with any other crop. Our alcohol plant is going on experimenting. We are running molasses, running artichokes, running different grades of corn, different mixtures of grain. We are running every possible product of the farm on experimental runs through that plant. Meanwhile the oil supply seems to be dwindling in production and demand increasing and that significant curve I hope will not meet until we are prepared to do our part to ameliorate the diminishing oil returns.

Economic Research in the Textile Industry

By JOSEPH H. WILLITS *

I UNDERSTAND that my invitation to be with you tonight arose from a desire on your part to hear something of the study of textile integration now being made at the Industrial Research Department of the Wharton School of the University of Pennsylvania. However, I was asked to give only a part of my time to that subject. So I shall lead up to our study by a discussion of related matters first.

It is safe to presume that a certain question is in the minds not only of many people here but also of many persons throughout the industry. That question may be stated as follows:

* Dean, Wharton School of Finance and Commerce, University of Pennsylvania; Co-Director, Industrial Research Department, University of Pennsylvania; Executive Director, National Bureau of Economic Research.

"Is economic research in the fields of production and distribution and finance likely to be of as great value to the industry and to the public as research in chemistry, physics, and engineering has proved itself to be?"

This question pertains not only to the textile industry, but it pertains to every other industry, and even to society as a whole.

The mere statement of that question implies a doubt. The values of research and experiment in physical sciences have abundantly proved themselves all the way from the spinning jenny to the discovery of rayon and the development of vat dyes. Their contribution is proved. A long list of inventions, improved processes, and other results of a specific and practical kind stand to its credit. No one needs, before any intelligent audience, to argue the case any further.

At first sight the case for economic research seems somewhat more dubious. And the reasons are not far to find.

Economic vs. Technical Research

To begin with, in the fields of economic and other social science research we are perhaps a century behind the physical sciences in development. And anyone who has had any experience in research,—whether it be in the physical sciences or in economics,—knows that results from research are cumulative; that at the start in any area, no matter how well conducted, the results do not appear significant. The results at first are small. But if the effort is continued, one piece of research builds upon the one preceding and leads to the next. The results that at first came slowly soon begin to pile up and become more significant the longer the research is continued; that is, if the people at work are any good.

There are more fundamental causes of the question as to the value of economic research. In the nature of things, workers in economic research will probably never attain the same degree of precision, predictability and applicability of results as are found in the physical sciences. Economics concerns itself with the activities of men, and these are too various and uncertain to predict with accuracy. In economic research we are much closer to the meteorologist predicting the weather or the doctor diagnosing a disease than we are to the chemist telling what result will come from the mixing of certain chemical formulae or to the astronomer predicting when there will be an eclipse.

The best statement of tendencies in a field involving human conduct, human prejudice and emotion, human interest and motive, and human psychology, "must needs be inexact and faulty."

Furthermore, economic research does not produce a specific result like the spinning mule or a new dye. It produces an idea or a problem or a statement of a tendency in production, in wages, in merchandising, or in finance. You cannot hook that to a loom and say, "Go ahead; turn out the yards." It is of value chiefly in the formulation of business policy; in making business a little less a game of blindman's buff. It helps you see where you are headed and where the industry as a whole is headed, and also where the public is headed. It may help keep you out of the ditch but it is not a device that will go on rolling up the black figures while you sleep.

That brings me to a third reason for doubt about the utility of economic research. That lies in the fact that a large proportion of executives are, by training and long experience, ready to use, and have learned how to use the results of technical research. The opposite is the case in economic

research. The background and ability to use technical research are there; some have had but more have not had the training and experience to interpret and utilize the economic data. That is one of the factors which gives extra significance to the study, now being made under the auspices of the Textile Foundation, of the possibility of introducing some education of an economic character into the technical textile training course.

Alternatives of Economic Research

Does all this mean that the case for economic research is hopeless? To me it does not mean anything of the kind. It merely means that the problem is different and that the task is more difficult and a larger proportion of the work lies ahead.

Let us look beyond the textile field for a moment and see what the alternative to economic, governmental, and social research is. Our only alternative is to try to solve problems by dialectics, and "hunch," and gullibility and prejudice and catch words and slogans, all worked by pressure groups on one side or another. As a matter of fact, we have built a society that is so complicated and so inter-related that it is easier to make half-truth and untruth appear simple and plausible than it is to make the more complicated thing which is truth itself, understandable and clear. Since we have just been through a political campaign, I do not believe that statement needs any elaboration.

At the same time we have speeded up the means of communication through radio and in other ways. The very brevity of these means of communication gives extra opportunity to trade on ignorance or gullibility. In other words, as our problems have become more complex we have multiplied the power to educate or to misrepresent. At the same time, the disappearance of free land and the apparent inability of society to avoid large amounts of persistent unemployment have released powerful social forces which involve a widespread interest in economic issues. That interest can lead to wise action or it can lead to stupid action.

Economic Research Laboratories

The only way of which I know to increase the probability of intelligence is that we understand, as precisely as we are capable, the nature of economic facts and economic, political, and social relationships. We have laboratories for the studies of physical sciences; we are equally in need of laboratories for the study of economic change. We need to "enlarge the area of definitely ascertained fact upon the basis of which useful public (and private) action may confidently rest." I know of no other course that is safe for a democratic society.

It is considerations such as these which give meaning to the organized research which is being done at such institutions as Harvard University, at the National Bureau of Economic Research, at the Brookings Institution, at the Food Research Institute at Stanford, at the Massachusetts Institute of Technology, and at the Industrial Research Department at the Wharton School of the University of Pennsylvania, and at other places. They are the beginnings of our laboratories of economic change.

The Issue Before the Textile Industry

But we are here tonight because of our common interest in the textile industries. What is the pertinence of all this to textiles? The answer is

that the economic problems,—in production, in distribution, in labor, and in finance,—are just as pressing as the general problems which confront society. The alternative before the textile industries is just as clear as the alternative confronting society as a whole. I think the issue before you might be stated in the following question: "Do you believe that, at a time when we have passed from a long period of rising prices to a period where the reverse may be true and intense competition will be the result; when textile men are faced with kaleidoscopic changes; when many of the forces which make for success or failure in the industry are outside the plant and not inside; at such a time, I say, do you believe that the industry should stick its head in the sand and not try to analyze and understand its deeper lying economic trends in a systematic way?"

The question, of course, answers itself.

I do not believe that the textile industries are willing to yield the right of way to other industries which are competing with you for the consumer's dollar. Nor do I believe that textile leaders will lag in their search for the most intelligent solution of their industry's problems, and thereby in helping society to solve its economic issues.

You know the problems better than I. But I can merely mention a few of the fields:

1. Pricing policy and price changes from stage to stage in the production and distribution of textile products.
2. Tracing at every stage of production the effect of inventory held at that stage.
3. Influence of low-cost areas on the textile industries of the United States.
4. Effect of the differing rates of obsolescence on over-capacity in the various processes of the textile industries.
5. Effect of scale of operations on costs.
6. Effects of new shifts of power to the retail group, particularly its effect on legislation.
7. Possible effects of consumer co-operatives on the textile industries.
8. Inter-fibro competition.
9. The economic effects of multi-fibre processes (the same mill processing cotton, rayon, wool, silk, etc.)
10. Wages and labor policy.
11. Changing aesthetic standards and their effects on the textile industries.

Many of these problems transcend the scope of activity of single organizations. But they are problems that are of concern to the whole industry. You in textiles are fortunate among industries in having in your Institute for Textile Research a body which represents different elements and interests in your industries. You are also fortunate to have in the Textile Foundation a body with resources which, through your Committee on Economic Research, looks at the problems from an industry-wide standpoint. It seems to me that you are in a position to do a pioneering job.

The excuse for my being here is not to make these general remarks but to tell of our study of integration in the textile industries. I suppose that study is an example of the kind about which I have been talking.

Research Policies

Perhaps it would help you to better understand this study if I told you something of the way in which the Industrial Research Department of the Wharton School approaches its problems. In the work of the Industrial Research Department, we have followed a number of general policies of which I will mention only three:

1. We have been disinclined to undertake research in a given field unless we could carry on research studies in that area continuously. We believe that greater scientific and practical results flow from this practice. Moreover, co-operating groups expect a certain stability of policy from a university. Startings and stoppings are bad in research as in other matters.
2. We have always stressed co-operative research. We have always learned a good deal by working in close but independent co-operation with practical groups. We get first-hand material; we get a more complete sense of reality from such contacts; we are better able to define problems and to interpret the figures as a result of the experience and criticism of practical men.
3. We have stressed the study of whole industries. We have stressed the advantages of having one man working continuously with an assistant or two, on the economic problems of one industry. We feel that a man may contribute more by studying intensively year after year the economic problems of one industry than he will by studying the whole economic world, for one industry resembles the economic system in microcosm and it is possible to cover an industry in a fairly definite way. Moreover, there are practical advantages in having one man concentrating on one industry. Each industry needs to see itself as a whole and continuously more clearly than it does. For example, by studying trends in the installation of various kinds of machine equipment in the hosiery industry a research result of practical value to the industry is obtained.

Wool, hosiery, and upholstery are among the industries we have studied in this way. Our work in textiles has been continuing for eight years. It is upon that background and with these policies that we approach this study which we have undertaken for the Textile Foundation at the invitation of your Committee on Economic Research.

Trends Toward Integration

Now what you perhaps are most interested in hearing from me is something about the textile study we are making. You men are much more aware than I of the speed with which relationships between the various units in production and distribution in the textile industries are changing. I wonder whether changes are occurring so rapidly in any other industry or in so many different directions at once. A knitting or linking together

is occurring between many different parts of the industry and an opposite tendency is to be observed in others. Here the production of yarn and the production of gray goods are being combined. There the production of gray goods and the production of finished goods are being done under the same management. Then the retailers of certain lines of textile goods are tying up with the production of finished consumers' goods. And manufacturers of garments and other industrial goods are tying in, in one way or another, with textile manufacture. So far as I have heard, no consumers' co-operatives have become interested in textile manufacture, but if they develop as they have in Europe maybe they will. And, as I have said, while such tendencies are to be observed in some instances, the opposite tendencies exist in others.

As I understand our task, it is to examine in co-operation with your industry all these confused and often conflicting tendencies in organization of production and distribution of textiles in order to see what are the general trends and directions. And, what is more important than that, what, according to the experience of the industries, are the causes of those trends? What are the different influences which are making these tendencies go in one direction or another? You see, all we are trying to do is to write down the experience of your industries. We are not trying to tell you what you ought to do or "economically plan" your industry, but merely to record from your experience what is happening, what of the many possible forms it is taking, and something of why it is occurring. If all these confused tendencies can be made a little more clear and particularly the reasons for them, then each individual manager ought to be in a position to work out his own adjustments to these tendencies and forces more intelligently.

Now that is the task we have undertaken as I understand it.

But my colleagues have expressed our approach to the study much more definitely, and for fear they may not wish to be bound by my statement (they are a very independent crowd) I had better read to you their statement. It is as follows:

How Study Is Being Undertaken

"For each product, there are various stages in manufacture and distribution where activities may be either integrated or specialized. The nature of the integration may vary from a complete control by one management through ownership to an indirect integration whereby one management has partial control through different types of agreements, formal or informal.

"The prevalence of integration or of specialization at particular stages of manufacturing and distribution varies by products, and also at different phases of industrial development. Thus, the manufacture and distribution of silk apparel fabrics were generally undertaken by integrated units in past years, while at present these processes are performed by specialized units. In contrast, former specialization in the manufacture and distribution of wool apparel fabrics has been supplanted, to a large extent, by the development of integrated concerns. It is of moment to appraise any trends toward or away from integration at each stage in the production and distribution of textile products.

"With the above in mind, it appears that at any time certain forces tend to induce either integration or specialization. Some of these forces may be considered as inherent in the activities performed at a particular stage, such as the requirements of manufacturing a styled as contrasted with a staple article, or the inherent limitations imposed by the capital investment that it is necessary to perform a function. In addition, other forces may be classed as fundamental industry pressures. They include the existence of a buyer's or seller's market, the rate of style changes, inter-fiber competition, changes in distribution practices, shifts in living habits and standards, and changes in methods of financing.

"Efforts toward integration of various textile operations cannot be properly appraised except in relation to the situation in the industry at the time they were attempted. With this thought in mind the staff is employing the following procedure for each class of products under study:

"(1) an appraisal of the forces tending to induce integration or specialization at each stage of manufacture and distribution;

(2) a selection of individual companies that have tried integration of one form or another at various stages and under various industry situations;

(3) an analysis of each company's effort at integration, focusing on (a) the reasons prompting the integration, (b) the reasons accounting for successful results, or (c) reasons accounting for lack of success;

(4) an appraisal on the basis of individual company experience, of the possibilities for and the limitations to various methods of integration in relation to the circumstances under which they were attempted."

Procedure Thus Far

Now how are we going to work and what have we done so far?

We have been talking with a lot of people and have been receiving the very finest co-operation and help from the officials of the various textile associations and from many individuals in the industry. Most of all we have been helped by the members of your Committee on Economic Research.

Because the field of study is so broad that a careful selection of the particular products to receive emphasis is necessary, it has been deemed advisable to focus attention upon the production and distribution of woven and knitted fabrics. Other classes of textile products that are to receive attention include knitted apparel goods completed in textile mills, such as hosiery and underwear, selected examples of household textiles, and selected examples of industrial goods.

In closing let me say that we are under no illusions concerning the extreme complexity of the task or no delusions as to our own omniscience. We do hope to be able to put down for the benefit of the industries the significant trends in the industries and the reasons for them, as they re-

late to the problem of the study. We trust the result may be of some help. To make it successful we must have your help and criticism.

And let us remember that this is merely a study of one problem from the thousands which confront your industries. Do not expect this study to produce miracles. It can only help management to see some of its problems of policy a little more clearly.

The deepest significance of this study, apart from the practical results which may accrue, lies in three things:

1. The study is further evidence that the textile industries are interested to attempt the understanding of their economic problems factually and realistically, and on an industry-wide scale.
2. Textile leaders thereby recognize their obligation to help society in its solution of its economic problems by an orderly and objective attack upon that part of them which may lie in the textile field.
3. By uniting the efforts of men from the industries and men from a university in a study, practical experience and disinterested science are united in an approach that should produce a more useful result than if each were working separately and independently. Let us hope that much more of such collaboration will be attempted in the future between scientific men, whether within or without the universities, and practical men.

Why Textile Research?

By DR. E. H. KILLHEFFER *

MY connection is, as you know, with an organization † outstanding for its recognition of the value, yes, the absolute necessity of research. If therefore I convey to you some idea of this viewpoint, you may be able to draw some helpful analogies.

Scientific research is necessary in any industry that would preserve its present and seek to assure its future. Some of the most outstanding industries we can call to mind are established on this principle.

The textile industry has been slow to embark on a regular research policy. This has been true the world over but latterly in several countries textile research is well launched. Great Britain, as you know, is far ahead of us and even Japan is now getting started. In the United States the effort lags.

This Institute was founded for the sole purpose of promoting cooperative textile research here. Sad to relate there would have been no start at all in actual research if it had not been for money grants from the Textile Foundation, the Chemical Foundation and one or two textile manufacturers. Several important researches are now being conducted. They are supported financially by these grants and subscriptions from directly interested textile people.

What is needed is an awakening of the entire industry to its genuine need for a comprehensive research program.

* Executive Vice-President, U. S. Institute for Textile Research, Inc.
† E. I. du Pont de Nemours & Co., Wilmington, Del.

How Will Research Aid in Preserving the Present?

Certainly we cannot know too much about the materials with which we are working or the processes through which we put them. How much really do we know about cellulose? And how much about wool? The fact is we know very little. As we learn more about the materials and their behavior under varying conditions our processes often change. Perhaps some processes should be radically changed and possibly others omitted altogether.

This is not done in a moment. Invariably there must first be fundamental scientific research, the results of which lead to applied research and then finally reduction to actual mill practice. Time and money are required. No one mill organization can afford the financial burden. Cooperatively, the burden can be light. If the textile industries of other nations go after the fundamentals in this way, how can the American industry expect to hold its place if it neglects the opportunity? Research will aid in preserving your present.

How Research Will Aid in Assuring the Future

Do you think there will be no developments of things entirely new? Of course you don't. They will not be pulled, like rabbits, out of a hat. They will come as the result of painstaking study. Rayon didn't just happen. Who knows but what some bright mind will make a textile fabric much after the fashion that paper is made today, avoiding spinning, weaving, etc., or perhaps a way will be found, with the aid of proper buffers, to introduce wool into viscose just before it is extruded into threads or sheets. Perhaps some new treatment will make virtually new fabrics. When much more is known about the various fibres new possibilities are bound to open up. The research workers find and record a great mass of new facts which often are totally unrelated.

This is the fundamental part. It then remains for the practical man in industry, chemist, physicist or engineer, to study these new facts and make practical application of them in his own plant. The future is an unknown chamber. Research is the key with which to unlock it.

Excuses for Non-Co-operation Answered

The attitude of mind of a large part of the textile industry is apparently something like this: Research may be beneficial but we will wait and see what practical benefits, if any, come from the present studies and if, when and as there are any such benefits, we will join up and help support the work. Or, We have our own research department and whatever useful information we develop is for our own use; or, We are just struggling along one jump ahead of the sheriff now; how can we support financially a research program?

The first group wants to be shown something tangible. This really is a shallow pretense. Surely no person claiming to be even fairly well informed can truthfully say that he doesn't know of any number of extremely practical developments which have resulted from painstaking research study.

Mechanical refrigeration is a result of much study of the fundamentals of insulation and of refrigeration. Then manufacturers of stoves applied

some of the results of the insulation research and today we have cook stoves of an efficiency undreamed of a few years ago. We may know little of the intricate problems of electrical research but we certainly can see plenty of evidence all about us of the successful culmination of those researches. Could these things be, unless someone had become dissatisfied with the knowledge he possessed and decided to search out more of the why and wherefore and had the faith to believe the effort would be worthwhile?

With such examples as rayon, which certainly is no stranger to the textile industry, how can the industry honestly be skeptical of the benefits of research?

As to the organization that has its own research, what commercial textile organization can afford a research into fundamentals and how could a single organization cover so vast a field? Fundamental research is expensive. There must be a personnel adequate in training and number. Costly physical facilities must be provided and besides, much time is required. Older textile industries than ours have realized that the only feasible answer was co-operative research. As a result they could have the best trained people, equip them with proper facilities and cover a wide enough field. The Japanese, whose textile industry is much younger than ours, have been quicker to adopt this idea than we. The mill with its own research department is just in a better position to utilize any results of co-operative research.

Now for the much larger group who cannot afford the financial burden: it's all in the point of view. They continue to meet their power bills because they know they can't operate otherwise. They do not come in and make themselves a part of a big research program because they do not view it as essential.

Suppose the state department were to announce their intention of making a drive to increase exports of raw cotton and that they would propose in connection with this to reduce the tariff, which now protects the American cotton manufacturing industry, so as to make it easier for the purchasers of our raw cotton to ship into this country the fabrics manufactured from it. I think within a week the whole industry would be up in arms and willing to co-operate in any way that might seem to aid in their self-preservation against such a threat. They would recognize an imperative need to co-operate.

If every textile mill contributed or was assessed one-tenth of one percent of its annual sales the resulting fund would be approximately $2,500,000 per year. What a job of self-preservation, through research, could be done with that amount. By way of comparison the research expenditure by the organic chemical industry in the United States equals approximately 5% of dollar sales. The financial load would not be heavy if all the industry helped.

Research and Tariff Policy Interdependent

I mentioned your tariff protection. There is a thread to all Occidental industry and more particularly and immediately textiles. We are witnessing today something entirely new and very different from anything we have ever known—the industrialization of the Far East. It is unlike our similar development as a competitor of Europe. We were the same people with the same standards of life and our equipment initially at least was inferior.

In the Far East it is different. Their standards of life are not ours. It is not a question of whether higher or lower; it is vastly different and much less costly. And besides, they do not have inferior equipment but instead the latest and most improved. This it seems to me will compel us, whether we like it or not, to evolve some new system if we are to survive. Yes, the tendency over the years will be for their standards to more nearly resemble ours, but that will take a long time, if indeed our ideas of living are desirable from their point of view.

You must not lose sight of the fact that every time a tariff rate is reduced to some European country, that same reduction is extended automatically to Japan. Obviously, a rate that is just sufficient to protect us against European competition is totally inadequate protection against the industries of the Far East.

You in the textile industry think you know something already about this serious threat from the Orient. In my opinion you have only witnessed the beginning. Here is where research and tariff are interwoven. You must have one if you are to have the other. Without tariffs that protect you against abnormally low cost nations, you cannot support a research program financially. Without research that will keep you abreast of the times you can less easily justify tariff protection.

Mr. Hull puts the cart before the horse. He reduces tariffs not because we are independent of them but because in theory there should be no artificial barriers to trade. What he and all advocates of the present brand of Reciprocal Trade Agreements overlook is the fact that we in the United States have followed precisely this theory for many years. That is why we have the largest free list of any important nation. We have recognized that duties on such things as tea, coffee, rubber, etc., would be unnatural barriers because we do not produce them, hence they are on the free list. A tariff that protects the jobs of American workmen in already existent industries cannot fairly be called an unnatural barrier. It must be remembered in this connection that the textile industry is one of the largest employers of labor.

Your only chance of lessening your dependence on tariffs is to be far in advance of others in quality and production cost. As an example of such an industry we might cite the case of the automotive industry of the United States. If you are to be less dependent on tariff, it will come about through revolutionary developments which in turn are products of research.

Will you not spread this call throughout your large and important industry? The job can be done. It needs the support, financial as well as moral, of the entire textile industry.

I can close this short address in no more fitting way than to quote a paragraph from an address of Dr. C. M. A. Stine, Vice-President of the du Pont Company, on the subject "Science in Industry." He was referring to agriculture but his conclusions are equally appropriate to textiles.

"Here, verily, is unlimited opportunity for more science in industry. Let us see to the use of more fundamental as well as applied science in industry, as one sure means of assisting in determining the kind of a future our industries may confidently expect."

Torque Relaxation and Torsional Energy in Crêpe Yarn

By R. L. STEINBERGER*

Fellow of the Textile Foundation

Abstract

Earlier work has shown that there is a relation between the character of the pebble in rayon crêpe and the untwisting torque exerted by the yarn when wetted. In the present paper the torsional internal energy in twisted viscose yarn is investigated in detail. The torque released when thrown and set yarn is wetted is found to be independent of the commercial variation in filament number and twist. In twisting a parallel filament yarn the resisting torque due solely to internal stresses is directly proportional to the turns twist, and the corresponding torsional internal energy increases as the square of the twist. The relaxation of torque follows a simple law, the same for both the dry and wet conditions except for the constants of the equations. The torque falls off directly as the logarithm of the time. An explanation for the formation of kinks is given.

Introduction

IN an earlier report[1] it was pointed out that we must look to the torque released in the thrown and set yarn of the greige goods for the fundamental cause of pebble formation. The throwing operation imposes on the yarn severe internal stresses which are then greatly reduced in the setting or steaming operation in order to render the yarn more stable. Rapid dissipation of internal stress by shear readjustment takes place in the yarn while in the steam bath because of greatly reduced resistance to plastic flow. The remaining or residual stresses are held stationary by the great viscosity of the material when dried after steaming. However, in the "boil-off," the final operation in which the pebbled crêpe effect is produced, the residual stresses, although much weaker than the stresses in the yarn immediately after throwing, are still sufficiently strong to give rise to the characteristic kinks found in finished crêpe yarn. The kinks are the direct result of partial release of mechanical restraint, especially tension, in the greige goods yarn, so that the residual stresses have an opportunity to cause deformation. The character of the pebble pattern is intimately related to the condition of balance between the residual torques in the Z and S twist yarns and to the amount of shrink-

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age permitted in the fabric during the boil-off. It is apparent that for the control of pebble formation we must know in considerable detail the mechanism of internal stress in the crêpe yarn.

The present study is divided into three sets of experiments. The first set clears up certain matters left undecided in the previous study,[1] and also has to do with the effect of commercial variation in filament number and turns twist on the final residual torque. The second set has to do with the relation between torque and turns twist over the whole range of twist from zero to rupture by torsion, and also has to do with the torsional work stored in the yarn. In the third set of experiments, the manner in which the torque, due to internal stress, diminishes with time will be discussed.

Apparatus

Three types of apparatus were used: (1) a twist counter; (2) a device for measuring the decrease in length of a specimen of yarn as the twist was increased up to torsional rupture; (3) torsion balances for measuring the reaction torque in a yarn twisted to a known degree.

In each case, of course, the yarn had to be held securely and yet in such a way that the clamps would not injure it; such injury always resulted in premature rupture at one or the other of the clamps. Rupture at a point removed from either clamp was always used as the criterion of proper clamping technique.

For some of the first torque measurements the yarn was held in a very simple wire clip made from phosphor bronze wire bent into the shape shown in Fig. 1, A. The yarn was forced into the sharply bent angle, A.

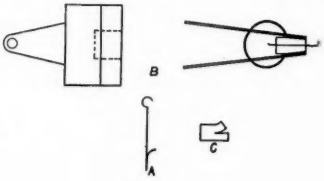


FIG. 1.

This is a very quick method, but is satisfactory only when small torques very far below the breaking stress are involved. The bending and squeezing of the yarn is so great as to introduce high stress concentrations and rupture in the clamp at large torques.

A thoroughly satisfactory clamp is shown in Fig. 1B, (two views), which is a very small paper or card clamp obtainable at most stationers. The clamping edge is only 7 mm. long. The clamps were first used to hold the yarn directly in their steel jaws. Again premature rupture occurred, this time at the hard metal edge. To avoid this a soft rubber square was cut as shown in Fig. 1, C. The slit was opened to receive the yarn. When released, the slit closes and the yarn is held securely by the grip of the rubber block, which was then in turn gripped by the spring clamp. In the twisting experiments at high torque it is necessary also

to anchor the free ends of the yarn by waxing them to the back part of the clamps by means of cement. Without the anchor the yarn will slowly creep through the clamp making any length determination worthless. The clamps are light and very satisfactory as attested by the fact that rupture always took place at a point removed from either clamp.

Twist counters are of obvious construction and are familiar to readers of this magazine. The one used here need not be described. It was constructed so as to serve as part of the device for determining the length contraction with twist.

The "contraction meter" is shown in Fig. 2. The twister, A, with its attached turns counter, B, was arranged to twist the yarn, C, in a horizontal axis. The clamp, D, was restrained in rotation by the wire,

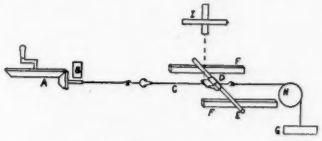


FIG. 2.

E, which could slide freely along the two horizontal bars, F. Known tension was provided by the weight, G, held by a silk thread passing over the frictionless pulley, H. The measuring microscope, I, focused on the edge of clamp, D, was used to measure the yarn shrinkage. Replacing the clamp, D, by one held more rigidly by a spring, we have the twist counter for determining the turns per inch in a yarn already twisted.

Two torsion balances were used. In measuring the torque relaxation as a function of time an instantaneous indication of the torque is necessary. Also to get a true value of the torque no appreciable untwisting of the yarn is permissible. To meet these and other specifications the balance schematically illustrated in Fig. 3 was set up. A rather stiff torsion wire was used. The small angle of torsion was measured with an optical lever. The apparatus of Fig. 3 was arranged to accomplish the following: (1) give an instantaneous measure of the reaction torque in the yarn; (2) apply a predetermined tension; (3) twist the yarn at a predetermined rate and to a known number of turns; (4) apply to the twisted yarn a water bath or other desired liquid reagent.

The torsion wire, A, (0.25 mm. phosphor bronze 51.4 mm. long) is soldered to the heavy brass wire, B, which is held in the friction clamp, C (a cork stopper). The right angle bend at the upper end of B serves as an adjusting handle. To the lower end of the torsion wire, A, is soldered another stiff wire shaft, D, provided with a hook at its lower end. Shaft D carries the rotating galvanometer mirror, E, and the damping vanes, F, which dip below the surface of the damping liquid, G (a light machine oil), held in the annular vessel, H. The yarn specimen, I, is held in tension between the two clamps, JJ. The hooks on the lower clamp hold the sliding link, K, to the lower end of which is hung the tension weight, L. It is necessary that the twist be inserted without disturbing the tension. This is accomplished by the spur gears, M_1 and M_2, the shaft, N, and the twister shown at the right of the fig-

ure. The parallel wires of the link, K, slide freely through two holes drilled through the axle of gear, M_1. The purpose of the somewhat complicated twisting mechanism is to permit the entire frame, P, to be surrounded by the vessel, Q. The specimen of yarn, under predetermined and constant tension may therefore be twisted a known amount under water or any other fluid, and the reaction torque can be measured at the same time. The twister gives a rapid rotation to pulley, R, which is belted to pulley, O. Turns of the twister shaft, S, are recorded on the counter, T. The gears, M_1, M_2, are equal in diameter, and so are the pulleys, O and R. The belt transmits the small forces involved without slip. Counter, T, thus gives the total yarn twist count.

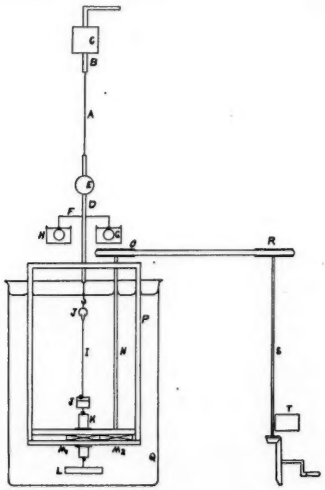


FIG. 3.

The angular turning of mirror, E, is read with a telescope and a scale at a distance of 150 cm. The torque measuring movement is mounted without bearings to avoid all friction. The torques to be measured are sometimes so small that even well made jewel bearings would have too much friction. The damping system (F, G, H) is very essential. Without it, building vibration makes reading impossible. Also without it, vibration set up by the twister dies down too slowly. Experiment readily decides the viscosity of the damping oil and the size of the vanes immersed in it. The sensitivity of the instrument may, of course, be changed by exchanging the torsion wire, A, for one of greater or less rigidity.

In some cases the telescope and scale do not permit sufficiently rapid torque determinations. A deflection type torsion balance was built to fill the need for a more easily read instrument. This instrument was

used in the experiments for which results are given in degrees deflection. The structure is clear from Fig. 4, which is purely schematic with supporting members leveling screws, etc., omitted. The torsion wire, A, is held between the rotating knob, B, and the stiff wire shaft, C. The yarn specimen, D, 50 mm. long, is held as usual between the clamps, E, E. On the lower clamp hangs the tension weight, F, which is provided with two horizontal wires which engage the tines of the fork, G, to prevent untwisting. Fork G may be turned in its holder so that the wires on the weight, F, just touch the fork before a reading is to be made. Friction

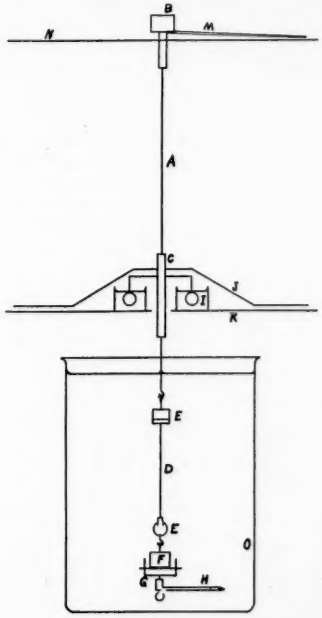


FIG. 4.

prevents rotation of the fork under the torsion exerted by the yarn. As in the other balance, a damping device is provided at I. Twisting of the lower end of the torsion wire, A, is indicated by the double ended needle (JJ), made from fine aluminum tubing to cut down the rotational inertia. The needle (JJ) sweeps over a large graduated circle, K. The double needle is an advantage, for it marks a diameter of the rotating system and aids in adjusting the scale, K, concentric with the rotating system. The rotating knob, B, is also provided with a needle (M) which sweeps over another graduated circle, N. If it is desired to make a reading with no untwisting of the specimen knob, B, may be rotated to keep the needle (JJ) at zero.

The specimen may be immersed in water held in the beaker, O. This torsion balance was used in making the measurements previously described.[1]

If great sensitivity is desired, and rather long and thin torsion wires are used, the balances must be shielded from draughts. This is especially necessary in the case of the deflecting balance of Fig. 4, because of the long needle (JJ). A transparent box made from sheet celluloid was placed around the rotating system of the deflecting balance. The constant for the torsion wire in each balance was determined from the oscillation period of a disc of known moment of inertia attached to a known length of the wire.

Method and Results

In the manufacture of crêpe yarn practical considerations prevent the maintenance of absolute uniformity in turns twist per inch and filament number. Now it has been suggested[1] that the pebble pattern of finished crêpe is dependent on the magnitude of the residual torque released in the crêpe fabric in the boil-off. The torque variation may be directly dependent on this accidental twist and filament number variation. If such were the case, torque and resulting pebble could be controlled by adjusting twist and filament number. In the experiments previously described,[1] no especial care was exercised to have the specimens all of the same length. The torque

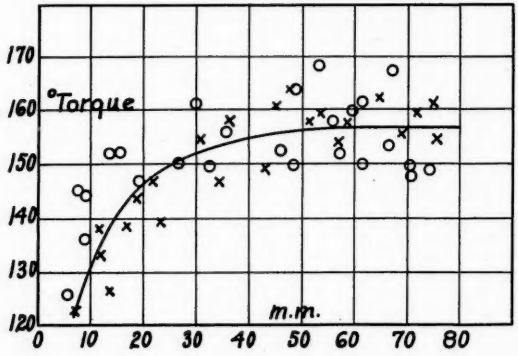


FIG. 5.

variation found along the length of the yarn may have been a spurious effect due to variation in test specimen length. To clear up these doubtful matters, four experiments were made to answer the following four questions:

(1) Does the torque depend upon the length of specimen used for test?
(2) Is the torque variation along the length of yarn described in reference[1] a real variation, or is it due to differences in specimen length;

(3) Does the residual torque bear a direct relation to the naturally occurring variation in turns twist inserted by the throwing operation?

(4) Does the torque bear a direct relation to the naturally occurring variation in filament number?

A number of speciments of thrown and set crêpe yarn varying in length from 5 to 80 mm. were tested for the release of residual torque when immersed in water. The results are plotted in Fig. 5 with ordinates in degrees torque and the abscissa in millimeters specimen length. There is a large scattering of points not due to experimental error but due to actual fluctuation in residual torque. However, it is quite evident that the torque does vary with specimen length, increasing to a reasonably constant value for lengths greater than 40 mm. The convenient length of 50 mm. was therefore chosen as standard.

Now that a variation of torque with specimen length has been discovered, it is necessary to repeat the test for torque uniformity along the length of the yarn, using specimens of accurately equal length; *i.e.*, 50 mm. The results are given graphically in Fig. 6. There is a real and random variation in torque along the length of the yarn not due to variation in specimen length.

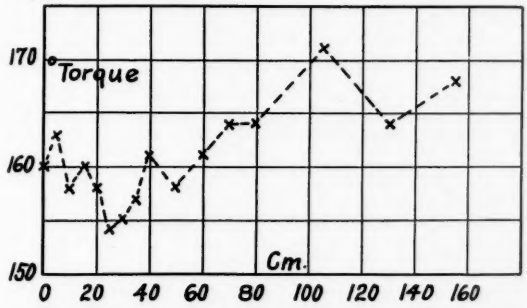


FIG. 6.

To answer question (3), the twist and torque release in a number of different yarns were determined. The results are ploteed in Fig. 7. The yarn for Plot 7A was taken from the S-twist quill, Sample No. 2,[1] and represents a thrown and set, but unwoven, yarn. Specimens 50 mm. long were taken at intervals of 30 cm. along the length of the yarn. The yarn for Plots 7B and C were taken from Sample No. 1, Table II;[1] B from the good or low pebble area, and C from the high pebble area. The results are given graphically to show that no smooth curve, other than possibly a horizontal straight line, can be drawn through the points of a given series. Therefore, the naturally occurring variation in turns twist found in the yarn has no direct relation to the torque released when the yarn is immersed in water.

There is a naturally occurring variation in filament number from yarn to yarn, which, in the high pebble area of Sample No. 1, Table II,[1] runs from 53 to 63. The magnitude of this variation is in itself quite surprising considering the customarily accepted idea of great uniformity in synthetic

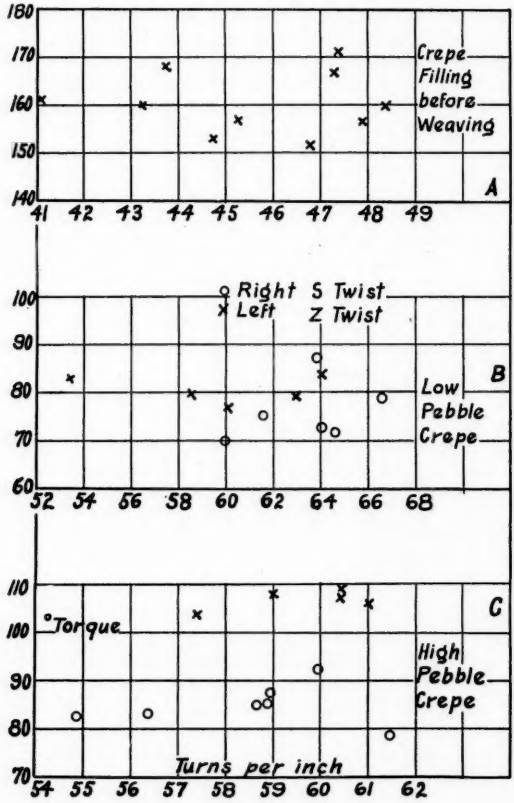


FIG. 7.

yarns. In spite of this naturally occurring large variation, Fig. 8 indicates that there is no clear cut dependence of torque upon it.

The general conclusion to be drawn from the answers to the four questions is that the torque release in a given type of yarn does not depend in a very sensitive manner upon the naturally occurring yarn variations, but upon the amount of torsional energy initially put into it, diminished by the

dissipation of the potential energy of internal strain as a function of the slow readjustment in the dry conditions or the rapid readjustment in the steaming and in the boil-off.

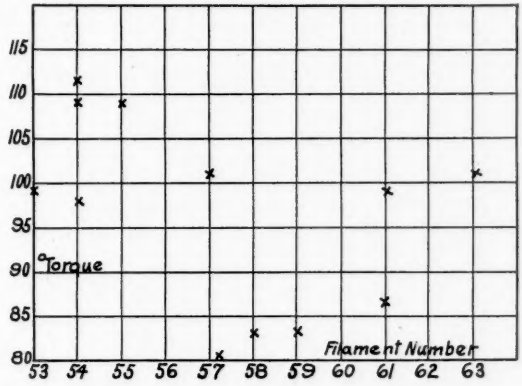


FIG. 8.

Relation Between the Torque and the Degree of Twist

As the straight parallel filament yarn is twisted there is a steadily increasing amount of torsional energy put into it. It is important that we know how this energy of torsion varies with twist. We could get at the torsional energy through a measurement of the resisting torque if it were not for the fact that tension on a bundle of twisted filaments produces a torsional component of stress, and in any twisting operation tension is necessary in order to prevent tangling and kinking. The net value of the torsional energy was arrived at by correcting for the work done against the tension during the twisting operation.

The static tensile strength of the 40 filament, 150 denier viscose yarn used in these experiments was determined by loading a pan, hung on a 20 cm. length, with fine shot. The breaking loads in grams were as follows: 304, 327, 310, 283, 314, with an average of 307. The tests were made at a room R. H. of 53%, and a temperature of 21.4° C. Considerable creep sets in at tension far below the static breaking stress as determined above. The twist versus torque determinations were for this reason made at a low tension; only 10% of the breaking stress, or 31 g.

Two sets of experiments were carried out: one to determine the relation between decrease in length of the yarn as a function of twist turns; the other to determine the relation between total torque and turns twist; each experiment using the same tension, namely 31 g. From the decrease in length, the work done against the tension of 31 g. can readily be computed. The two experiments lead to the curves of Fig. 9 and Fig. 10.

The contraction was determined in the apparatus of Fig. 2. A 50 cm. length of 40 filament, 150 denier viscose yarn was used in each of the four

runs made at the relative humidities recorded in Fig. 9. Twist was applied in steps of 10 turns. One-minute relaxation was allowed before each contraction determination. Considering the nature of the phenomena, a very good curve was obtained and the several runs check well with each other except for the end near the point of rupture, which occurred between 105 to 116 turns twist per 50 mm., or 53.3 to 59.0 turns per inch. The average total contraction being 7.3 mm. in 50 mm., or 14.6%.

For the total torque vs. twist relation the torsion balance of Fig. 3 was used. Total torque includes both the torque resistance due to internal strain

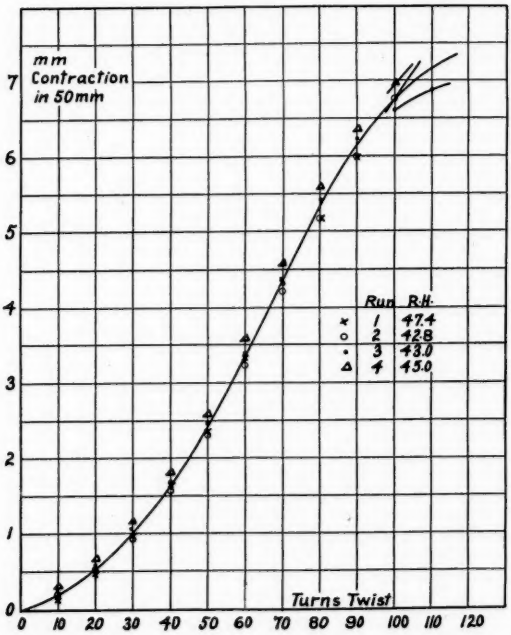


FIG. 9.

and the torque due to tension. The data from four runs are given in Fig. 10. The experimental procedure, except for torsion measurement, was the same as in the contraction experiment: 50 mm. of 40 filament, 150 denier viscose; twist in steps of 10 revolutions; 1-minute relaxation; 31 g. tension. The R. H. is higher than for the contraction experiments. This should cause no trouble at the present level of precision of the experiments. Up to 80 turns the four runs agree very well. Above 80 turns we are approaching rupture and greater variation is naturally to be expected. However, over the entire course of the run a very good average curve can be drawn. The

ordinates are directly read scale readings which may be converted to cm. gram torque values by multiplying by the torque factor 0.01227 cm. gram per cm. deflection. For purposes of computation the average values read from Fig. 10 were converted to torque in cm. grams and replotted. The curve has the same shape as the curve of Fig. 10 and need not be given

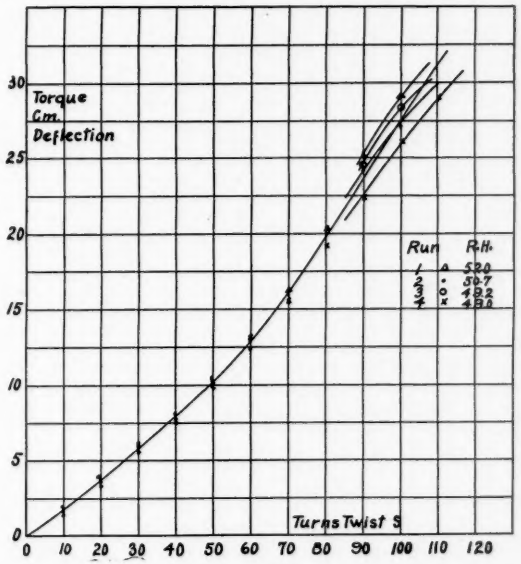


FIG. 10.

here. The average torque at rupture was 36.5 x 10^{-2} cm.-grams, with an average rupture twist of 106 turns in 50 mm., or 53.9 turns per inch at a tension of 31 grams.

From the two curves of Fig. 9 and Fig. 10 we can compute the relation between twist and energy stored or expended in the twisted yarn exclusive of the energy expended against the tension. Let Fig. 11 A and B represent respectively the two curves of Figs. 9 and 10. In Fig. 11 A, e is the contraction in cm.; in 11 B, T is the torque in cm. grams, while θ is the twist in turns. The total work done against the tension F in twisting the yarn to θ turns is W_g, and

$$W_g = \bar{e}F \tag{1}$$

where $\bar{e}$ is the average length change between conditions $\theta = 0$ and $\theta = \theta$. From the familiar expression for the average ordinate of a curve we have then

$$W_g = (F/\theta)\int_0^{\theta} e \, d\theta \tag{2}$$

The total work of twisting W_T up to θ turns is

$$W_T = 2\pi \int_0^{\theta} T \, d\theta \tag{3}$$

because torsional work is equal to torque times the angle in radians through which the torque acts. The net work W_n expended in twisting the yarn is then W_T diminished by W_g or

$$W_n = W_T - W_g \tag{4}$$

The two integrals

$$\int_0^{\theta} e \, d\theta \quad \text{and} \quad \int_0^{\theta} T \, d\theta$$

can readily be evaluated from the curves of Figs. 9 and 10, for they are represented by the areas under the curves up to the abscissa θ, Fig. 11.

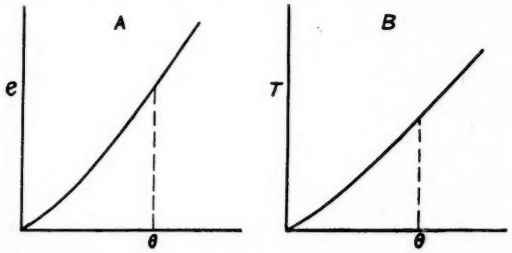


FIG. 11.

Multiplying the first by F/θ we have W_g for each value of θ, and multiplying the second by 2π we have the corresponding values for W_T. In Table 1 are given the computed values for W_T, W_g and W_n all in gram centimeters of energy.

TABLE 1

Torsional Energy in Twisted Viscose Yarn

turns θ	Energy in gram centimeters			Torque $W_n/2\pi\theta \times 10^2$
	W_T	W_g	W_n	
10	.66	.0279	.63	1.002
20	4.28	.68	3.60	2.86
30	9.54	1.23	8.31	4.41
40	16.30	1.94	14.36	5.72
50	24.78	2.80	21.98	6.98
60	35.10	3.82	31.30	8.30
70	47.90	5.00	42.90	9.73
80	63.20	6.26	56.94	11.31
90	81.60	7.54	74.06	13.10
100	103.2	8.82	94.40	15.01
106	117.6	9.53	108.10	15.91

In the last column we have the quantity $W_n/2\pi\theta$, which is the net torsional energy put into the yarn divided by the torsional angle expressed in radians. In other words, it is the resisting torque in cm. grams exerted by the twisted yarn by virtue of the internal stresses alone. The torque exerted by the tension on the spiral structure has been eliminated. Introducing T_n for $W_n/2\pi\theta$, we can plot T_n against θ and obtain the curve, Fig. 12, and this

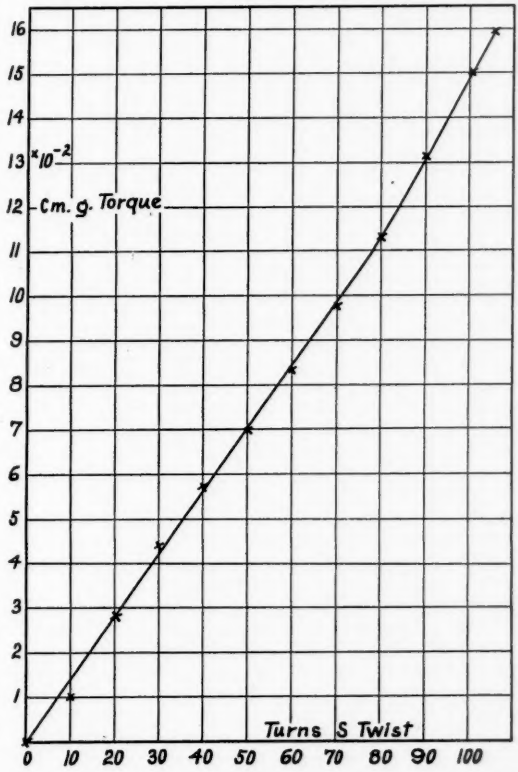


FIG. 12.

is the final result. Over a long range of twist, from zero to nearly 90 turns in 50 mm. (45.7 turns per inch), the relation between T_n and θ is linear. Even at the point of rupture (106 turns) the departure from the straight line is less than 10% of full scale torque. The resisting torque is directly

proportional to the number of turns twist:

$$T_n = k\theta \tag{5}$$

and

$$W_n = 2\pi k\theta^2 \tag{6}$$

We reach the interesting conclusion then that when a parallel filament yarn of viscose is twisted, the energy stored in the yarn at the moment of twisting increases as the square of the angle of twist, or the number of turns of twist.

Relaxation of Torque

Immediately after a viscose yarn is twisted it tends to untwist with a torque directly porportional to the angle to which it has been twisted. However, this torque at first falls very rapidly, then more slowly as time increases, the tension and angle of twist being kept constant. This decrease of torque with time will be called torque relaxation. It is important that we know something about the rate of relaxation and how moisture affects it; accordingly, some relaxation experiments now to be described were made.

A 40 filament, 150 denier viscose yarn, 5 cm. long, was set up in the torsion balance of Fig. 3 under a tension of 31 grams. A twist of 100 turns to the right (S twist) was inserted in the 5 cm. length in a period of 25 seconds. At the end of the 25 seconds twisting interval, measurements of the torque relaxation were started, at first at 15-sec. intervals because of rapid rate of relaxation, then less frequently as the torque relaxation rate decreased. The R. H. of the room was 63.0%. In Fig. 13 the relaxation results are given, with cm. g. torque plotted against time of relaxation as measured from the instant twisting was stopped. The first point, at 0.355 cm. $\times$ g. for time zero, is too small, because the relaxation continues during the twisting period and also falls too rapidly to measure accurately for values of time near zero.

The complete relaxation curve for this particular specimen has five separate sections. The whole program of treatment of the yarn was arranged to simulate the treatment the yarn would receive in practice; however, the similarity is not intended to be very exact. For example, for the steaming operation a simple immersion in room temperature water was substituted. The actual steaming technique is much more drastic, but would differ from the simple immersion mainly in the magnitude of the effect.

Immediately after the dry twisting of the yarn to 100 turns in 5 cm. (50.8 turns/inch) the torque has a value near 0.356 cm. gram, which falls very rapidly in the first ten minutes of relaxation, thereafter more slowly. The rate of relaxation falls off according to a fairly definite law, the character of which will be discussed later. In the dry condition, the relaxation continues indefinitely as indicated by the A section of the curve. Section A represents the manner in which the torque relaxes in the throwing operation and during the period in which the yarn is stored on spools waiting for the steaming operation.

At the end of two hours relaxation in the dry condition, the yarn was suddenly immersed in room temperature water. There is a very sudden drop in torque at the beginning of section B, which represents the torque relaxation under water. At first it appeared that the low points at the

start of section B were spurious and that the curve fell as at the beginning of section A. However, careful examination of the data forces the admission of all points. On the first contact with the water the torque suffers an immediate and large drop from 0.240 to .166 cm. gram, then climbs up to a maximum of .188 at 45 seconds immersion, then settles down to a steady relaxation similar to that of section A. The character of section B is well illustrated in Fig. 14 where the initial time scale is expanded. Section B represents the relaxation in the steam bath, with this difference, that in the actual steaming operation the drop in torque would be more severe.

At the end of one hour in the water the bath was taken away and the yarn was allowed to dry. The torque fell during drying as indicated in section C, which simulates conditions obtaining as the yarn dries after being withdrawn from the steam bath. The scattering of points in section C is due to irregular drying. The torque continues to fall, because, as the filaments dry, the viscosity becomes so high that the small residual stresses cannot relax through plastic flow. In one hour torque falls from 0.166 cm. gram when taken from the bath to the constant value of 0.063 cm. gram, representative of the dry twisted yarn under a tension of 31 grams.

At the end of section C the 31 grams tension was removed. The torque fell from 0.063 to 0.01 cm. gram. The lower clamp was freed. The yarn untwisted elastically one-quarter turn. The yarn was rigid and set in the twisted state. The high viscosity in the dry state prevented further untwisting. But this does not mean that the internal stresses had been entirely eliminated. They simply have been reduced to a low value. The state of the yarn, when released from all constraints at the end of section C of the relaxation curve, is representative of the crepe yarn in the greige goods.

Section D represents the condition of torque when the greige goods is immersed in the boil off bath, which in this case was water at room temperature. After 45 minutes' drying (section C) the 31 g. tension was again applied to the dry yarn. The torque rose to 0.063 cm. gram, the first point on section D. This is the value of the torque called into play by tensioning the spiral bundle of filaments. The water bath was then applied to the yarn. The torque rapidly rose to a maximum of .176 cm. gram in 1.5 minutes, then began to fall off along a curve which soon settled down to a continuation of section B, and continued to relax as long as the yarn was wet. It is quite obvious that the internal stresses are still present, and are able to cause lively untwisting if all restraints are removed and the yarn is wetted. Ninety-two per cent. of the rise in torque occurs in the first 30-sec. of immersion. In spite of the small diameter of the individual filaments, this represents a very rapid diffusion of water molecules into the solid interior of the cellulose. In the fabric the torque released in the boil off does not cause untwisting because of the frictional restraint of the woven structure. Shrinking is, however, permitted. That is, the thrown yarns are not held under tension, so that partial release of the torsional energy is permitted by the formation of kinks.

Section D continued for two more hours. At the end of this period the yarn was again dried, this time over-night, and the next morning, in the dry condition, was released from all restraint with an elastic untwisting of the lower end of about 45°. The tension was again imposed and the

bath brought up. Again the torque rose, this time to a maximum of 0.1690 cm. g. in 1.5 minutes. Torque relaxation followed branch E, which settled down to a continuation of D. Branch E represents the condition of torque release in a finished crêpe fabric when wet. The torques are considerable and shrinkage is quite likely to result as long as the fabric is wet. The alternate "freezing" and release of the torque of internal stresses can be brought about as often as desired by alternate drying and wetting of the yarn.

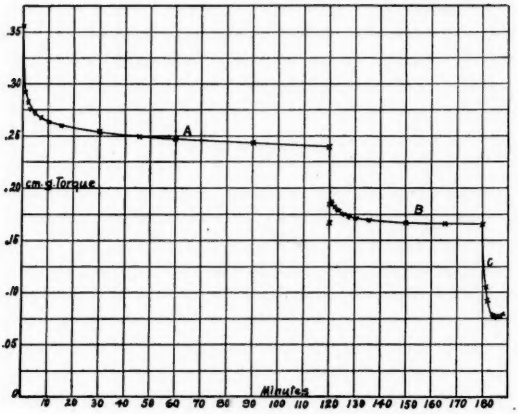


FIG. 13a.

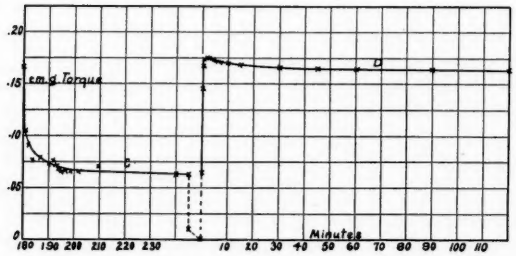


FIG. 13b.

In an attempt to arrive at an equation representing the relaxation of torque along the branches (A, B, D, E), Fig. 13, the data are replotted in Fig. 14, with torque in cm. g. as ordinates and the logarithm of the time as abscissa, and using the same designating letters, namely, A, B, D, E, for the four branches. Branch C is not plotted in Fig. 14, for it has no

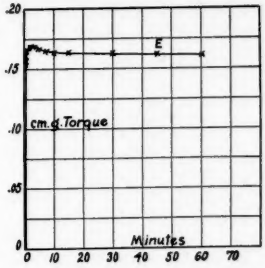


FIG. 13c.

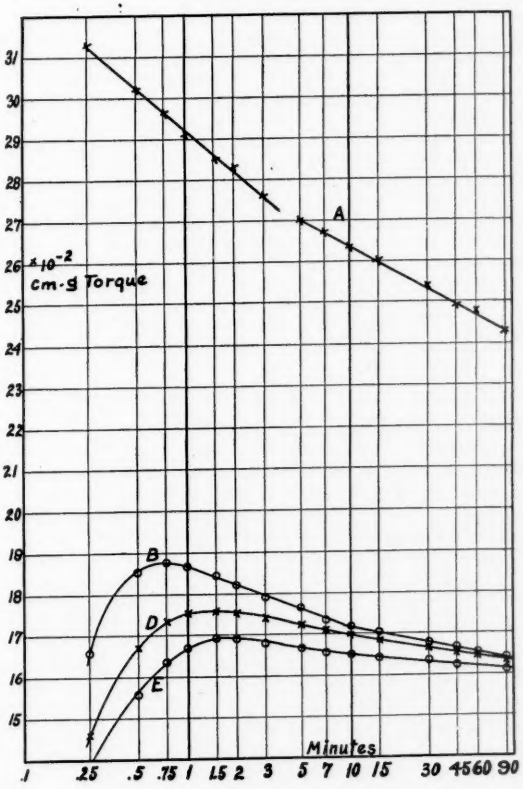


FIG. 14.

important significance. Branch A is, of course, much higher than B, D and E, and seems to be made of two linear segments. A slightly curved line also fits fairly well, but not as well as the two straight lines. The first relaxation of torque in the dry yarn, therefore, follows the law

$$(T_1 - T) = k \log t \qquad (7)$$

where k has two slightly different values, one for each linear segment. T_1 is the value of the torque when $t = 1$ minute. In the other segments, B, D, E, the points before the maxima are of little interest, for water penetration is imperfect and the relaxation has not yet reached a steady state. Note particularly the similarity between B, D and E branches. There is some evidence that beyond the maxima we again have two linear segments in each branch, but it is not conclusive. Again, as an approximation, we may use Equation 7 for the relaxation. Note the seadily decreasing value of the torques from B to E.

Equation 7 is the type discovered in p. 204,[1] which represents the "relaxation" of elongation e under constant tension, namely

$$(e - e_1) = k \log t \qquad (8)$$

The rate of change of elongation was

$$de/dt = k/t \qquad (9)$$

In the present case the rate of change of torque is

$$(dT/dt) = (-k/t) \qquad (10)$$

Both the rate of change of elongation under constant tensile stress, and the rate of change of torsional stress under constant torsional displacement, are inversely proportional to the time of stressing.

Final Conclusions and Discussion

Regenerated cellulose is a comparatively soft material, in which changes in shape begin the moment unsymmetrical (i.e., non hydrostatic) forces are imposed on it. Any stress system at a point in a solid body may be reduced to a pure shear and a hydrostatic pressure or tension. The deformation due to the shear stress is a change in shape only while that due to hydrostatic stress is a dilatation or change in volume only. Now, in relatively soft bodies, Poisson's ratio is found to be close to 0.5, which means that dilatation in simple tension is zero. This result suggests that in any unsymmetrical stress system the dilatation will be negligible compared with the shear deformation. Shear deformations, opposed by the resistive force of viscosity, set in at very small stresses and continue as long as stress is imposed, but unlike a fluid the rate of shear deformation decreases. In a fluid, the rate of shear deformation continues at a constant value under the constant shear stress. The word viscosity is thus not strictly applicable fo solids, although one can find in the tables values for solid viscosities. For example, the viscosity of ice is listed as 10^{16} times the viscosity of water.

One of the distinguishing characteristics of crêpe fabric is the existence of kinks in the yarn. These kinks are the direct cause of pebble formation.

What bearing does the system of latent internal energy, discussed in the foregoing, have on the formation of kinks? How can the energy of internal stress, measured here in terms of a torque, act so as to produce kinks? The high twist imposed on the yarn by the throwing operation sets up severe internal stresses, which are then greatly reduced by a steaming operation to a degree which makes the yarn stable and not subject to tangling or untwisting when handled. The stresses can only be made active by reducing the viscosity of the cellulose by wetting. When a body in the form of a slender shaft is twisted without external tension by opposite torques applied at the two ends, the outer elements of the cylindrical surface are forced to take the form of spirals and are under tension. The inner filaments near the axis, which suffer little or no spiral deformation, are under longitudinal compression in order to balance the tension in the outer filaments, for the whole shaft is in equilibrium. Definite formulas for the stresses can be found in books on elasticity. If the torque on the solid shaft is increased until the shaft ruptures by torsion, failure will occur by shear at the surface along a 45° spiral. Here we are not dealing with a solid shaft, but with a bundle of slender parallel filaments. Considered as a unit, shear rupture at the surface of the yarn along spiral elements is possible from the very start of twisting, because there is no shear strength other than the very slight one due to friction between adjacent filaments. Another effect also begins as soon as twist is started. The inner, relatively untwisted filaments, are under compression reacting against the longitudinal pull of the outer filaments. The inner filaments, taken as a whole, form a slender column which is unstable under a compressional load and fails by buckling, which is thus the start of a kink. The prime object in applying tension is to keep the center fibres of the bundle from buckling.

The type of deformation which the internal stresses in the thrown and set yarn can cause when the yarn is wetted, depends upon the manner in which external constraint is applied. If the tension is held fixed, but the yarn is free from torsional restraint, simple untwisting will occur with no buckling. If untwisting is prevented, but the tension is released, buckling will occur. The latter is the condition existing in the greige goods in the boil off. Friction of the weave prevents twist and the fabric is allowed to shrink; *i.e.*, no tension is applied to the crêpe yarn.

The conclusions which may be of value to the manufacturer of crêpe fabrics will now be summarized.

(1) In a given type of crêpe fabric, the kind of pebble finish obtained is dependent upon the magnitude and uniformity of the torsional energy in the yarn at the boil-off operation. The amount of the torsional energy is measured by the torque released when the yarn is immersed in the boil-off bath.

(2) The torque in the thrown and set yarn does not depend in any significant degree upon the normal factory variation in twist or in filament number.

(3) The torsional energy expended in twisting a parallel filament yarn increases as the square of the angle of twist, provided we correct for the work done against the tension. This law holds accurately up to about 80% of the rupture twist, and to a good first approximation right up to rupture.

(4) The torque with which a parallel filament yarn resists twisting, is directly proportional to the angle of twist, provided we subtract the torque

due to tension. This result is a corollary of (3) and holds under the same conditions.

(5) After a yarn is twisted, the resisting torque decreases in direct proportion to the logarithm of the time, no matter whether the yarn be wet or dry. Only the constants in the equation need be changed to fit the wet or dry condition.

Reference

1. Pebble Formation in Rayon Crepe. R. L. Steinberger. *Tex. Rsch., VI,* 8, 381–91 (1936).

(*Continued from P. 42*)

been engaged for some two years in discussing various phases of the textile merchandising problem that finally developed into the economic study that has been in progress under Dean Willits of the Wharton School of Finance and Commerce since last June, and was described by him at the recent annual meeting. This, as is generally known, is wholly financed by the Textile Foundation and has the co-operation of the leading textile associations; but that which may not be fully appreciated is that the Committee on Economic Research had to "sell" to these bodies the project that they had planned, and which they are now sponsoring. Eventually, they and all of the co-operating bodies will be accorded the credit that is due them.

These two projects, and the research on textile drying which is now being co-operatively financed by the Institute, constitute the research program for which congratulations are being received. However, they are too early to apply specifically to the textile drying study, for at this writing twenty more subscribers at $100 each are needed to complete the financing and start the study. They may prove immature also if the results of these researches fail to meet all expectations.

It can be predicted confidently, however, that eventually it will not be the starting of specific projects, nor the specific results of those research projects, which will be the subject of congratulations that the industry will come to realize are most merited by the Institute, but, rather, the unselfish work of the active members of the corporation and of those who have aided the financing of their work.

Dr. E. H. Killheffer stated in his address "Why Textile Research?" at our recent annual meeting, that "If every textile mill contributed or was assessed one-tenth of one per cent of its annual sales the resulting fund would be approximately $2,500,000 per year. What a job of self-preservation, through research, could be done with that amount!" But instead of one-tenth of one per cent of annual sales the industry is contributing annually to the support of our research program less than one-thousandth of one per cent, this including all income from dues and research financing, but not including funds received from the Textile Foundation. Equally significant is the fact that the bulk of this small income is contributed by less than 100 co-operators. Therefore, while a relatively small group of active research workers and their financial supporters merit and appreciate congratulations on their accomplishments, they regret that as yet they are unable to extend reciprocal congratulations to the whole domestic textile industry for its broad research mindedness and its generous support of scientific and economic research.

Acetylation of Silk Fibroin by the Action of Ketene

By MEARL A. KISE and EDWARD L. CARR *

Fellows of the Textile Foundation

Summary

It is shown that the free amino and free hydroxyl groups of silk fibroin are blocked by treatment with ketene,[1] yielding a modified protein. The study of this ketenized fibroin will be continued in this laboratory this coming year.

Silk Fibroin Constitution

SILK fibroin is one of the natural proteins which does not contain sulphur. According to the present conception of protein structure, it is composed of a group of selected α-amino acids joined together by means of characteristic groupings—$NHCH_2CO$—known as polypeptide linkages. Its amino acid composition is expressed in Table 1, where are recorded the analytical results obtained by Abderhalden[2] and which account for 83.3% of the fibroin molecule.

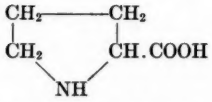
According to these analytical results three α-amino acids—glycocoll, alanine and tyrosine—constitute 76.5% of the silk fibroin molecule. This substance occupies, therefore, an unique position in the field of natural proteins, and may be considered at present as a definite chemical entity.

Silk fibroin possesses, in addition to a small number of free carboxyl groups and a negligible quantity of free amino groups, a comparatively large number of free tyrosine hydroxyl groups.[3] These groups influence to a large extent such properties as the isoelectric point and the acid-base combining power of the fibroin molecule. Therefore, if these groups should be blocked, either by alkylation or acylation, a fibroin of decidedly different chemical and physical characteristics would be expected to result. The effects of such group blocking would be expected to be reflected in such properties as dyeing characteristics, stability to the action of light and moisture,[4] tensile strength, density, etc. Such group blockings with substitution of hydrogen atoms in NH_2 and OH groups should affect profoundly the micelle structure of fibroin. Hence, the ultimate objectives of any process of acetylation of silk fibroin are to produce a silk fibre possessing

* Dr. Kise was a Senior Fellow of the Textile Foundation during 1934–35 working under the personal direction of Prof. Treat B. Johnson, Sterling Professor of Chemistry, Yale University. His research program was taken up by Dr. Edward L. Carr in 1935, who was appointed a Senior Fellow of the Textile Foundation for 1935–36.

TABLE 1

Amino Acid Content of Silk Fibroin

Amino Acid	Formula	Percentage (%)
Glycocoll	NH_2CH_2COOH	40.50
Alanine	$NH_2CH(CH_3)COOH$	25.00
Leucine-isoleucine	$(CH_3)_2CH.CH_2CH(NH_2).COOH$	
	$CH_3CH(C_2H_5).CH(NH_2).COOH$	2.50
Serine	$HOCH_2CH(NH_2).COOH$	1.80
Proline		1.00
Phenylalanine	$C_6H_5CH_2CH(NH_2).COOH$	1.50
Tyrosine	$HO.C_6H_4CH_2CH(NH_2).COOH$	11.00
		Total, 83.30

greater resistance to the action of sunlight and moisture, and having modified and novel dyeing properties.

Blocking the Amino and Phenolic Hydroxyl Groups of Silk Fibroin

Previous attempts to block the free amino and free tyrosine hydroxyl groups of fibroin by benzoylation and acetylation by the action of acid chlorides and anhydrides, although successful chemically, led to an alteration of physical structure and consequently to considerably damaged fibres.[5] It is evident from the results thus far obtained that a new technique must be adopted, which can be applied without hydrolytic action, if a practical acylation of silk fibroin is to be accomplished successfully. In the present investigation an attempt has been made to acetylate silk fibroin without subjecting the silk fibres to the deteriorating action of the acidic secondary products furnished by the action of acetyl chloride and acetic anhydride. For this purpose, we have applied the novel method of exposing dry, degummed silk fibres to the action of ketene gas ($CH_2.CO$).

It is well known that ketene—CH_2CO—is very unstable when exposed to the action of water, alcohols and amines, and combines with them to form acetic acid, an ester and an amide derivative of this acid respectively. The ketene is more reactive towards amines than alcohols. That ketene is reactive towards phenolic hydroxyl groups is shown by the work of Van Alphen.[6] The difference in the reactivity of ketene with an amino group (NH_2) on the one hand, and water on the other is so great that Bergmann and Stern[7] were able to acetylate α-amino acids successfully in aqueous solution with ketene gas. Glycocoll and leucine were acetylated with excellent yields in the absence of alkali. The results of their experiments on acetylation in aqueous solution are shown in Table 2. It is an interesting

TABLE 2

Ketene on α-amino acids

1. NH_2CH_2COOH Glycocoll	$CH_3CO.NH.CH_2COOH$ Acetylglycocoll	Yield of 87% at 18°
2. $NH_2CH(CH_3)COOH$ dl-Alanine	$CH_3CONHCH(CH_3)COOH$ Acetylalanine	Yield of 90%
3. $NH_2CH(CH_2CH(CH_3)_2)COOH$ dl-Leucine	$CH_3CONHCH(CH_2CH(CH_3)_2)COOH$ Acetylleucine	Yield of 100%
4. $NHCH(CH_2C_6H_5)COOH$ dl-Phenylalanine	$CH_3CONHCH(CH_2C_6H_5)COOH$ Acetylphenylalanine	Yield of 85%
5. $NH_2CH(COOH)CH_2CH_2COOH$ Glutamic Acid	$CH_3CONHCH(COOH)CH_2CH_2COOH$ Acetylglutamic Acid	Yield of 90%
6. $NH_2CH(CH_2C_6H_4.OH)COOH$ Tyrosine	$CH_3CONHCH(CH_2C_6H_4O.COCH_3)COOH$ Diacetyltyrosine	Yield of 87%

fact that both the amino (NH_2) and phenolic hydroxyl groups of tyrosine react with ketene in aqueous solution. In the light of the results of these interesting experiments by Bergmann and Stern, it would be predicted that a protein molecule containing free amino or hydroxyl groups would react with ketene gas to form a modified protein. So far as the authors are aware the behavior of ketene towards a protein has been examined in one case only. Herriott and Northrup[8] succeeded in preparing crystalline derivatives of pepsin by treating this enzyme with ketene. They found that the activity of pepsin is decreased by acetylation, and was more rapid when the pepsin was applied at pH 5.0–5.5 than at pH 4.0–4.5. The treatment with ketene led to a difference in solubility of the pepsin, a variation in the amino-nitrogen content, and to differences in the isoelectric point and specific gravity of the enzymatic protein respectively. The results of the authors' preliminary investigation of the action of ketene on silk fibroin will now be discussed.

Experimental: Materials and Apparatus

Silk Fibroin: A skein of good quality Italian yellow silk, weighing about 70 grams, was degummed by treating it with 1500 ml. of a 1.5% solution of Ivory soap at 90–100° C. for 20 minutes. The skein was then rinsed twice in a liter of hot water. The soap solution and rinsing treatments were repeated three times. Finally, the fibres were soaked 20 minutes in distilled water at 60° C. The silk was then pressed free of water, extracted for 10 minutes with acetone and again soaked in water at 60° C. for 10 minutes. After pressing free of water and again soaking in acetone for 10 minutes, the fibres were extracted in a soxhlet with ethanol for six hours and the excess of ethanol pressed out. The fibres were then extracted

with ether, air dried at 212° C. and stored in a desiccator. The weight of the degummed skein was about 38 g. Samples of this skein weighing about five grams each were exposed to ketene gas.

In addition to the above skeins of Italian silk, commercially degummed skeins of Japanese white silk weighing about 5 g. each were used for experimentation. These skeins had been degummed, washed and dried at the mill, and with the exception of one skein, which was given a further degumming treatment, were used as received.

Ketene: The ketene gas was prepared by the pyrolysis of acetone according to the procedure described by Hurd,[9] and also that used by Rice.[10] Both porcelain filled and empty pyrex pyrolysing tubes were used. Acetone vapors were passed into the tube maintained at a temperature of 650–700° C. by heating in an electric furnace. The rate of introduction of acetone vapor was regulated to such a value that from 8 to 10% was decomposed. The yield of ketene was determined by passing the chilled pyrolysis vapors into a train of bubbling towers containing standard alkali and estimating the amount of alkali used in an aliquot portion. In this way ketene was obtained in yields of 25 to 50% of the weight of acetone decomposed.

Ketenization of Pure Fibroin: Samples of the silk fibroin described above, weighing about 5 g. each, were used in the ketenization experiments. These samples were air-dried at 212–215° F. in a silk conditioning oven and stored in a desiccator to prevent absorption of moisture. Exposure to ketene was carried out in the following manner: A sample was suspended in a glass chamber (Brühl receiver) connected to the ketene generator, and was exposed to the passage of the cooled pyrolysis gases containing ketene for one hour. The glass chamber was then closed and the silk was allowed to remain in the atmosphere of ketene for four hours. For the series of experiments recorded in Table 3 this procedure represented one ketene treatment. It was given to different samples from one to six times, as indicated in Table 3.

TABLE 3

Sample	Ketene Treatments (hrs.)		Millon's Test	Ninhydrin Test	% acetyl
	Hot	Cold			
0	0	0	+	+	0
1	1		−	−	5.2
2		2	−	−	7.3
3	3		−	−	7.1
4		4	−	−	7.2
2 after dispergation					6.0

In order to study the effect of temperature upon the ketenization process, samples 1 and 3 were exposed to the hot vapors of ketene and acetone as they issued from the pyrolysis tube. The temperature of these gases at the time of contact with the silk were not greater than about 212° F. At a higher temperature the silk was rapidly charred by the action of the ketene gas mixture.

After each sample had been given one or more ketene treatments, it was steeped in a cold 1% sodium bicarbonate solution for several minutes. When carbon dioxide ceased to be evolved and the pungent odor of ketene disappeared from the fibres, the fibroin was rinsed several times with hot water. The silk was then extracted with acetone in a soxhlet for six hours and finally with ether for the same period. Each sample was then dried and stored in a desiccator. The samples after this treatment were of a pale yellow color.

In order to establish that the free tyrosine hydroxyl groups had been blocked by this ketene treatment, Millon's test was applied to the ketenized samples. As ordinarily prepared, Millon's reagent is strongly acidic. Since in acetic esters of phenols the ester linkage is relatively labile in the presence of H^+ or OH^- it is to be expected that the strongly acidic Millon's reagent will eventually give the red color test in the presence of such an ester grouping, due to hydrolysis. This was found to be the case with phenyl acetate and with acetyl salicylic acid (aspirin). In the case of acetylated silk a negative reaction with Millon's reagent could be obtained by preparing the reagent in such a way as to minimize the acidity. Toward this end mercury was dissolved in an excess of concentrated nitric acid and the solution boiled until crystals began to form. The solution was then diluted to twice its volume with water and the white turbidity just removed by the dropwise addition of acetic acid. With this reagent phenyl acetate and acetyl salicylic acid showed no color reaction in the time required for the corresponding unacetylated phenols to give a deep red coloration characteristic of the test.

The Millon reaction was carried out on acetylated fibroin as follows: To 4 ml. water in a test tube were added 2 drops of the Millon's reagent, prepared as described above. The turbidity which resulted by this dilution of the reagent was removed by dropwise addition of dilute acetic acid. To the clear solution of the reagent was added a small quantity of shredded fibres of the ketenized silk. A similar test was applied to unacetylated degummed silk. The two test tubes were immersed in a water-bath at about 50° C. Unacetylated silk fibroin became red in about five minutes under these conditions, while the acetylated fibroin (ketenized) remained unaffected in the same length of time. The test was considered to be negative if the sample of ketenized fibroin could not be distinguished from a blank at the end of the time required for unketenized silk to acquire a deep red color. Samples of ketenized fibroin which analyzed to an acetyl value of about 5% gave a negative test under these conditions.

The blocking of the free amino groups was evidenced by a negative color reaction with the ninhydrin[11] reagent. This test was carried out on the fibres suspended in the reagent. The blue color formed quickly at about 60° C. and pervaded the solution of the reagent surrounding the fibres. A negative reaction with ninhydrin was also obtained on some samples which gave a positive Millon reaction, indicating a greater reactivity of ketene for amino groups in the protein than the phenolic hydroxyl group.

The extent of the acetylation by the action of ketene was determined by a method differing only in certain details from that of Kögl and Postowsky.[12] Samples weighing about 0.1 g. were dried in a vacuum over calcium chloride and the dry weight accurately determined. These samples were then gently refluxed with 10 ml. of 1 N. sodium hydroxide solution in a 125 ml. Claisen flask from which the side arm had been sealed off. A Kjeldahl distilling

trap was attached to the curved neck and a soda-lime tube employed to shut out carbon dioxide from the atmosphere. During refluxing the straight neck was closed with a rubber stopper. Under the gentle refluxing the water vapor condensed in the distilling trap. Refluxing for 45 minutes was sufficient to remove all the acetyl groups. A sample refluxed for four hours gave the same acetyl value as those refluxed for 45 minutes. This treatment with sodium hydroxide gave a clear amber colored solution. After refluxing, the solution was acidified with 3 ml. of 85% phosphoric acid and steam distilled. The distillate of from 60 to 80 ml. was titrated with a standard base, using phenolphthalein as an indicator. A blank correction was made on the titrations. In order to make certain that the bicarbonate treatment entirely removed the adsorbed ketene and acetic acid, sample 4 was allowed to remain 15 hours in a sodium bicarbonate solution at room temperature. The acetyl value was compared with that of the samples treated in the less drastic manner. The dried fibres of the sample overexposed to bicarbonate solution disintegrated when rubbed gently between the fingers.

Further evidence concerning the stability of the ketenized silk fibroin was obtained by dispergating 2 g. of the ketenized sample 2 in 50 ml. of neutral lithium bromide solution at 80° C. The shredded silk was stirred into the solution in small portions over a period of 20 min. The solution was then diluted with an equal volume of water and slowly stirred into 5 volumes of acetone. The precipitated fibroin was removed by filtration and macerated with hot water until the washings were free of bromide ions. The fibroin was then extracted with acetone in a soxhlet for six hours, dried and stored in a desiccator. The acetyl value of this dispergated sample is recorded in Table 1.

Discussion

Upon the basis of about 10% of tyrosine, commonly reported to be in fibroin,[15, 2] and the negligible number of free amino groups present in fibroin, complete acetylation of the tyrosine hydroxyl groups and the free amino groups should lead to an acetyl value of about 2.5%. However, values up to 7.3% were obtained depending on the duration of exposure to ketene. Nevertheless, in all cases the ninhydrin test for free amino groups was negative, and for acetyl values of 5% or greater Millon's test was negative. These tests indicate that the active groups were blocked by the ketenization process.

The higher acetyl values might be due either to the reaction of ketene with other than the free primary amino and hydroxyl groups of the protein, or to the polymerization of the ketene to diketene prior to addition. In the former case the groups other than hydroxyl and amino most likely to react with ketene would be the secondary amino groups of the peptide linkages. In the event the ketene either partly or completely polymerizes to diketene prior to addition to the protein an acetyl value of about 5% would correspond to complete blocking of the tyrosine hydroxyl groups. This view is supported by the fact that a sample which analyzed about 2.5% acetyl value gave a strong Millon reaction. The ninhydrin test in this case, however, was negative.

The fact that sample 4, which was soaked in sodium bicarbonate solution an excessively long time, had the same acetyl value as samples 2 and 3

indicated that the high acetyl values were not due to absorbed acetic acid or ketene. Furthermore, the dispergation treatment of sample 2, which would have removed every trace of adsorbed acetic acid, lowered the acetyl value from 7.3 to 6% only.

Thus, it was apparent that excessive exposure of fibroin to ketene gas led to the introduction of more acetyl groups, as shown by the method of analysis, than were required to combine with the original free amino and free hydroxyl groups. We also have to consider here the possibility of a large protein molecule (fibroin) undergoing disintegration to simpler molecules by action of the ketene.

Increased temperatures of ketenization up to 100° C. produced no effect upon the acetylation process, since samples 1 and 2 had no higher acetyl values than those ketenized at lower temperatures.

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"*I am convinced by nineteen years of close association with scientists, although with no scientific education, that the greatest gift to the country, of research, and of the chemical industries, will be the spread of that scientific habit of thought in the solution of our national, our local and our personal problems. The search for truth shall set us free.*" HON. FRANCIS P. GARVAN.

Abstracts

This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwarz, Chairman, M. W. Weiss, Dr. Irving J. Saxl and C. H. Clark.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Staple Rayon: Advance (of the use) of—in Foreign Countries. Haelge. *Deut. Wollen-Gewerbe,* 1936, V. 68, P. 820–3; *C. A.,* 1936, V. 30, Col. 6205. (W)

Staple Rayon: Most Recent Achievements in the Field of. Esselmann. *Chem. Ztg.,* 1936, V. 60, P. 533–6; *C. A.,* 1936, V. 30, Col. 6205. (W)

Staple Fibre Rayon. New Short Cuts and Continuous Processes in the Chemical Fibre Industry. Harold B. Vollrath. *Chem. Industries,* 1936, V. 39, P. 21–3; *C. A.,* 1936, V. 30, Col. 6205. (W)

Staudinger Viscosity Law in Rayon Manufacture. A. Zart. *Kunstseide,* 1935, V. 17, P. 38–42.

This article is a reply to Prof. Staudinger who complained that the detn. of mol. wt. according to his viscosity law (*C. A.,* V. 28, Col. 6120) has not been given sufficient attention in the rayon industry. Z. reviews Staudinger's investigations of the relation between viscosity and mol. wt., and discusses the possibility of applying this method in the investigation of celluloses used in making rayon and of the intermediate products and the final rayon. Z. concludes that the viscosity law can have only limited applications in such studies. (From *C. A.,* 1936, V. 30, Col. 2011.) (W)

Strength of Regenerated Silk Fibres and Their X-ray Diagrams. C. Matano and M. Nakamoto. *J. Soc. Chem. Ind., Japan* 39, Suppl. binding, 1936, P. 194–7.

Elongation curves, ultimate strength data and X-ray photographs of a no. of regenerated fibres are presented, and the effect of mech. action upon orientation of the micelles is discussed. Conclusions: By applying tension alone to the fibre, the micelles whose angle between their direction and the direction of the tension is larger than some critical angle, do not rotate, and if rotation is desired, the fibre must be placed in a state of semicoagulation or swelling. (From *C. A.,* 1936, V. 30, Col. 6204.) (W)

STRUCTURE OF CELLULOSE. F. Worschitz. *Magyar Chem. Folyóirat*, 1934, V. 40, P. 60–4; *C. A.*, 1936, V. 30, Col. 5407. (W)

TEXTILE FIBRES OF VEGETABLE ORIGIN: FORTY YEARS OF INVESTIGATION AT THE IMPERIAL INSTITUTE. The Textile Institute's (Manchester, Eng.) Mather Lecture, 1936. Ernest Goulding. *J. T. I.*, June 1936, P. P124–140.

The investigations reviewed were largely of a practical, and not of a fundamental, character. They covered thousands of samples of both wild and cultivated plants, the latter usually to determine the possibility of their adaptation to new locations, or to improve their quality. The author explains the factors that restrict or prevent utilization of many apparently useful fibres, such as ramie, the milkweeds or *Asclepias*, "pita" and other *Bromelias*, pineapple, palm-leaf and allied fibres. (C)

VERTICAL COTTON DRIER MAKES BETTER STAPLE. *Tex. Bull.*, July 30, 1936, P. 8, 16. (C)

WOOL: DETERMINATION OF THE DIELECTRIC CONSTANT OF. F. W. Holl. *Helv. Chim. Acta*, 1936, V. 19, P. 281–3.

The dielectric constant of wool, 4.56, is expressed as the quotient of the capacities of a cylindrical condenser, the insulting space of which is filled first with wool and then with air. (Copied from *J. Soc. Dyers Col.*, June 1936, P. 233.) (C)

WOOL: ITS PHYSICAL AND CHEMICAL PROPERTIES. P. Goldsmid. *Papier*, 1936, V. 39, P. 47–53.

A brief review of the chem. compn. of wool and of its chem. and phys. properties. (From *C. A.*, 1936, V. 30, Col. 2390.) (W)

WOOD PULP FOR THE RAYON INDUSTRIES. L. Hebbs. *J. T. I.*, July 1936, P. P169–80. (C)

WOOL QUALITY: SOME CHARACTERISTICS AND THEIR ESTIMATION IN THE FLEECE. A. Blakey Wildman. *Tex. Rec.*, 1936, V. 54, P. 40–1; *C. A.*, 1936, V. 30, Col. 5799; *J. T. I.*, July 1936,, P. P181–96. (W)

ZIG–ZAG ATOMS MAKE SILK STRONG. Thos. Lonsdale. *Silk J.*, 1936, V. 12, No. 144, P. 14.

By X-ray evidence, the cells appear to be in columnar arrangement, and the cell size to be 7.00 X 9.68 X 8.80 A. as calcd. from the position of the spots in the photograph. Each cell space is taken up by 2 C and 1 *N* atoms arranged in zig-zag form at an angle of about 109.5°, as the backbone of the chain. Wool has a similar structure. (From *C. A.*, 1936, V. 30, Col. 5419.) (W)

II. YARNS AND FABRICS

ACETATE WARP YARNS: COMPARISON OF. Anon. *Am. W. & C. Eptr.*, Aug. 6, 1936, P. 7–8, 39.

Describes a series of tests, the variations of results in which indicate the desirability of more exhaustive study of different acetate and viscose yarns along similar lines. (C)

ADEQUATE HUMIDITY IN SPINNING. A. W. Thompson. *Tex. Wld.*, June 1936, P. 90–1; abstracted by special permission from *Parks' Parables*, June 1936.

13% improvement in breaking strength of filling yarn (cotton) result of adequate humidity in spinning. (C)

BRADLEY KINETIC WARP LET-OFF MOTIONS. *Tex. Mfr.*, June 1936, P. 223.

Positive automatic, but frictional and gearless, warp let-off motions use a patent "kinetic" brake. The warp tension is maintained at a constant average throughout the weaving of the beam without attention, and stopping or starting marks in rayon and other fabrics are avoided and "evenness" ensured. (C)

COTTON WARP SIZING: NOTES ON. Ralph Hart. *Tex. Bull.*, 1936, June 4, P. 5–7; June 11, P. 6, 10, 24; June 18, P. 4–5, 26; June 25, P. 26, 46; July 9, P. 6, 8–9. (C)

CRÊPE YARNS. Otto Pennenkamp. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 125–6.

A review of the manuf., properties and applications in the textile industry. (From *C. A.*, 1936, V. 30, Col. 2390.) (W)

DELUSTERING VISCOSE RAYON IN THE PIECE. G. S. Ranshaw. *Tex. Mfr.*, June 1936, P. 232. (C)

DISPERSIVITY OF STARCH SOLUTIONS AND THEIR CHEMICAL BEHAVIOR WHEN APPLIED TO TEXTILES. W. Seck. *Mell. Textilber.*, 1936, P. 147; *Rayon & Mell.*, June 1936, P. 45.

The degree of dispersivity of the starch-water system is one of the characteristics of its colloid state which is more subjected to change. The chemical examination of starches in regard to their dispersivity raises a number of technical questions which are of interest to the textile industry. A way is pointed out by which the scientific treatment of sizing and finishing problems is made possible at last, leading to fields of research which even at the present time are still regarded as being the last preserves of pure empiricism. (C)

FINISHING OF DRESS AND COATING FABRICS: PRACTICAL. IV. DRYING OF WOOLENS. G. L. Atkinson. *Tex. Col.*, Mar. 1936, P. 195–7.

Describes various types of drying machines used for woolens and worsteds, but its practical value is seriously impaired by its failure to define temperatures, time of drying, moisture contents of materials to be dried and during drying, relative humidities of the air, the critical temperatures at which degradation or damage may occur. (C)

FLAX AND HEMP YARN DRYING: THEORY AND PRACTICE IN. J. Barbour Pears. *Tex. Mfr.*, May 1936, P. 184–5.

Two types of air-drying machines are described. So-called safe maximum temperature limits are given for a number of textile materials. (C)

FLAX YARN QUALITIES AND TYPES. S. A. G. Caldwell. *Tex. Mfr.*, 1935, V. 61, P. 402–3, 443, 489; *C. A.*, 1935, V. 29, Col. 5664; 1936, V. 30, Col. 869, 1235. (W)

HARD TWIST: MULTI-FILAMENTS FOR. Anon. *Am. W. & C. Rptr.*, May 21, 1936, P. 9–10, 13–14.

Tests on hard twisted synthetic yarns of several producers show important effect of number of filaments on their tensile strength and elongation. (C)

HARD TWISTED SYNTHETIC YARNS. Anon. *Am. W. & C. Rptr.*, 1936, May 7, P. 9–10, 16–17; July 2, P. 7–8.

Variations in values shown by comparison of two supposedly identical yarns as to their reaction in hard twisting. (C)

HOSIERY: CHARACTERISTIC DEFECTS OF—FROM MERCERIZATION. J. Pinte and A. Delhalle. *Rev. gen. mat. color.*, 1935, V. 39, P. 472–80.

A series of tests are described, illustrated by diagrammatic curves. (From *C. A.*, 1936, V. 30, Col. 1236.) (W)

WEAVING: EFFECT OF FRICTION IN. Anon. *Am. W. & C. Rptr.*, Apr. 10, 1936.

In this investigation it has been proven definitely and clearly that: (1) No warp fabric made of single cotton yarns is likely to be any amount stronger with any number of picks per inch than the total average single strand strength of the yarns employed in weaving the cloth. This is entirely contrary to market and technical ideas as to fabric tensile strength. (2) Considering the tensile strength of the warp fabric there is a general progressive loss in strength as the number of picks per inch are increased. (3) There is a regular or progressive loss in the tensile strength of the warp yarn as the number of picks per inch are increased. (4) The percentage of loss in yarn strength, through an increase in the number of picks per inch, is increased by a larger number of ends per inch. (5) It is entirely possible for a filling fabric to be produced, starting with much weaker filling yarns, which actually is stronger than the warp fabric, starting with much stronger warp yarns. (6) More net tensile strength is obtained by increasing the picks per inch above a certain point, and regardless of the fact that the warp fabric loses some tensile strength. (C)

WEIGHTED SILK: TENDERING IN LIGHT. G. Colombo. *Boll. uff. R. Staz. Sperim. Seta*, 1934, V. 4, P. 73–5 (through *Chem. Zentr.*, 1935, ii, P. 2308).

Experimental evidence indicates that the photo-chemical tendering of weighted silk, leading ultimately to the liberation of ammonia, is a process of oxidation. Suggestions are made (in the original) for modifications in methods of weighting. (From *J. T. I.*, Mar. 1936, P. A132.) (C)

WEIGHT UNIFORMITY IN COTTON SPINNING PREPARATION. *Tex. Mfr.*, May 1936, P. 169–70.

Routine of mill testing for regularity of weight per length necessary to lead to regularity of yarn is described. (C)

WINDING SILK: ECONOMY IN METHODS OF. O. Bitzenhofer. *Tex. Mfr.*, April 1936, P. 131.

A systematic mill study of winding raw silk, made with a view to standardizing conditions. (C)

WOOL: ACTION OF LIGHT ON. P. W. Cunliffe. *J. T. I.*, Feb. 1936, P. T25–36.

Deals mainly with those properties, other than dyeing, which control the useful life of a fabric and with the changes which they undergo on exposure to light. (C)

WOOL: PROSPECTS OF MODIFYING—TO MANUFACTURING ADVANTAGE. A. T. King. *Tex. Mfr.*, Mar. 1936, P. 109.

Wool has unique chemical and physical textile properties both in resistance to degradation and in possibilities of chemical modification of elastic and other properties, which are now becoming understood. (C)

WOVEN COTTON CLOTH: STUDIES IN THE VARIABILITY OF PIECE LENGTH IN. A. W. Bayes. *J. T. I.*, Mar. 1936, P. T53–83; *Tex. Mfr.*, April 1936, P. 134–5.

This paper is a continuation and extension of unpublished work done by colleagues in the mill on the general problem of piece length variation in cotton cloth. The conclusion drawn from this work was that the irregularity arose from uneven action of the mechanism controlling the tension of the warp during weaving and that it was more pronounced in cloths woven on automatic looms in which regulation of tension was entirely mechanical, than in those woven in Lancashire looms where the tension was controlled by hand according to the judgment of the weaver. There appeared to be evidence that the last piece from a warp woven on an automatic loom was longer than those immediately preceding it. Observations made on a large number of pieces of cloth are presented graphically and are analyzed statistically. The analysis includes an attempt to show to what extent the variation can be attributed to recognizable mechanical defects, particularly of the sizing frame, and what part of it must be left unaccounted for. A good deal of the unaccounted irregularity no doubt arises from the action of the loom. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

DYEING PHENOMENA IN WOOL. Robert Haller. *Helv. Chim. Acta*, 1936, V. 19, P. 15–22.

Wool was broken down into its histological elements by long-time treatment with cold concd. NH_3 soln. The dissolved substance contains no tyrosine and no S, adsorbs iodine strongly and is colored by ammoniacal fuchsin which also stains the cortex cells but not the epithelium. The epithelium is permeable to certain colloidally dispersed substances and yet impermeable to molecularly dispersed solns. of diazotized sulfanilic acid. CottonRed 10B in the cold or on short boiling hardly tints wool but boiling for 10 min. produces a strong coloration which under the microscope is shown to be entirely in the cortex while the intact epithelium is uncolored. (From *C. A.* 1936, V. 30, Col. 3240.) (W)

DYEING REAL SILK WITH NAPHTHOL AS DYES. H. Görlich. *Mell. Textilber.*, 1935, V. 16, P. 441–3; *C. A.*, 1936, V. 30, Col. 3239.

Practical details for producing shades fast to most influences are given. (W)

DYEING WOOL WITH ACID DYES: THEORY OF. E. Elöd. *Mell. Textilber.*, 1936, V. 17, P. 67–9.

Alterations in the pH of the dyebath which occur during the dyeing of wool with acid dyes, indicate that acid, *e.g.* sulphuric acid, in the dyebath is first absorbed by the fibre and gradually replaced by the dye-acid. Adsorption is also involved to some extent, but diffusion of the constituents of the dyebath into the wool protein is more important. Diffusion depends on the particle size of the dye, etc. and is facilitated by thorough agitation of the dye liquor to prevent local exhaustion in the vicinity of the fibre. The chemical reactivity of the wool substance towards dyes depends also on the temperature of the bath, and dyeing proceeds so rapidly at the boil that it is suggested that proteolysis, or chemical degradation of the fibre substance, precedes dyeing. This is prevented by dyeing at a rather lower temperature, *e.g.* 80° C. Wool has a definite reactivity dependent on the pH of the dyebath, and maximum absorption of dye by the fibre occurs at about pH 1·3. Since degradation of the fibre increases when wool is dyed from an acid bath of lower pH, the additional practical importance of pH control during the dyeing of wool with acid dyes is indicated. It is suggested that the greater swelling capacity of chlorinated wool, is responsible for the increased velocity of dye absorption in comparison with non-chlorinated wool. Difficulties in obtaining level well-penetrated dyeings on thick wool or hair felts, are attributed to complete absorption of dye-acid and formation of non-dissociable salts at the surface layers of the fibre. Better penetration and more level dyeings are produced on such fabrics by impregnating with dye liquor at pH about 9–10, under which conditions the fibres have little or no capacity to form protein salts, and then acidifying. The proteins, thus rendered reactive, then combine with the dye-acid distributed homogenously throughout the fabric. (Copied from *J. Soc. Dyers Col.*, May 1936, P. 193.) (C)

DYES: ACTION OF LIGHT ON—OF SYNTHETIC ORGANIC COLORING MATERIALS. P. Mougeot. *Bull. soc. franc. elec.*, 1935, V. 5, P. 965–78; *Science Abs.*, V. 38B, P. 655; *C. A.*, 1936, V. 30, Col. 4676. (W)

DYES: ADSORPTION AT LIQUID-LIQUID INTERFACES. G. W. Gibby and C. C. Addison. *J. Chem. Soc.*, 1936, P. 119–27; *J. T. I.*, April 1936, P. A192.

Measurements have been made of (1) the adsorption of Congo red, methylene blue, methyl orange and orange II from various concentrations of each in water, at water-benzene and water-chlorobenzene interfaces, near 17°; (11) the interfacial tensions of the systems. The results show marked quantitative deviations from the predictions of Gibbs's equation in each of the eight cases. (C)

DYES: COMPARISON OF THE SEVERAL ADOPTED STANDARDS OF—FOR THEIR STABILITY TO LIGHT. A Wahl. *Rev. gen. mat. color.*, 1936, V. 40, P. 140–1.

Tables of the German, English and American standards are given. (From *C. A.*, 1936, V. 30, Col. 4325.) (W)

FINISHING OF RAYON FOR THE MANUFACTURE OF CRÊPE YARNS. Hans Hunlich. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 147; *C. A.*, 1936, V. 30, Col. 3244. (W)

FLUORESCENCE OF INTERMEDIATES AND DYES. P. Mougeot. *Rev. gen. mat. color*, 1936, V. 40, No. I–II.

Fluorescence theories are discussed. A no. of dyes and intermediates are classified in regard to their fluorescence in Wood's light. A revue is given of application of this knowledge. (From *C. A.*, 1936, V. 30, Col. 2389.) (W)

FUGITIVE TINTS. I. G. Sanford. *Tex. Wld.*, June 1936, P. 88–9.

Knowledge of properties is essential if users of these tints are to get the most good from them. (C)

IMPREGNATION: IS THE—EFFECT OF WATER-REPELLING IMPREGNATED WOOLEN FABRICS UNFAVORABLY INFLUENCED BY STEAMING OR THE USUAL AFTER-HOT-PRESSING? Bundesmann. *Monatschr. Textil-Ind.*, 1936, V. 51, Fachheft I, P. 18–19.

Tests are reported in which various textile fabrics were impregnated with Impregnol by the com. method in the usual concn. and then finished. The results given show that the after-finishing operations do not cause any decrease of the impregnation effect. (From *C. A.*, 1936, V. 30, Col. 4329.) (W)

INJURY OF COTTON FIBRES BY SALTS. Walter Neumann. *Mell. Textilber.*, 1934, V. 15, P. 305–10; *C. A.*, 1936, V. 30, Col. 2763.

The action of solns. of NaCl, Na_2SO_4, $MgSO_4$, $MgCl_2$ and $CaCl_2$ has been investigated. The injurious effect is proportional to the pH of the salt soln.; with concd. solns. other factors become evident. (W)

KIER BLEACHING OF COTTON FABRICS WITH SODIUM PEROXIDE. D. J. Campbell. *Cotton*, June 1936, P. 54–6. (C)

MERCERIZATION OF CELLULOSE. Germano Centola. *Gazz. chim. ital.*, 1935, V. 65, P. 1015–21; *C. A.*, 1936, V. 30, Col. 4328. (W)

MILDEWPROOFING AND WATERPROOFING OF TEXTILE FIBRES. Samuel Lenher and George A. Slowinske. *Am. Dye. Rptr.*, June 15, 1936, P. 326–31.

Paper presented at meeting, South Central Section of A. A. T. C. C., Feb. 22, 1936. (C)

OCCUPATIONAL DERMATITIS DUE TO HEAT DECOMPOSITION OF DYES. Louis Schwartz and C. D. Hooker. *U. S. Pub. Health Repts.*, 1936, V. 51, P. 493–509; *C. A.*, 1936, V. 30, Col. 4673. (W)

OILS AND OIL THICKNESSES FOR THE WOOLEN FIBRE. Hans Schneider. *Wollen & Leinen Ind.*, 1936, V. 56, P. 4–6; *C. A.*, 1936, V. 30, Col. 3244. (W)

OPTIMUM CONDITIONS OF WOOL SCOURING. S. S. Rakhlina and M. I. Plekham. *Sherstyanoe Jelo*, 1935, No. 3, P. 19–23; Nos. 4–5, P. 17–23.

The fats remaining on the wool after treatment in the successive scouring tanks have lower acetyl values and higher I values; the unsaponifiable matter, the acid value and the sapon. value are unchanged. The supposition that the high-melting fats remain in the wool at the end of the scouring is disproved. Removal of fat from wool is best accomplished with soap-soda solns. producing stable emulsions. (From *C. A.*, 1936, V. 30, Col. 2010.) (W)

ORGANIC SOLUTIONS OF DYES: APPLICATION. *Deut. Färber Z.*, 1936, V. 72, P. 67.

A short account of "dry dyeing." Most basic dyes are soluble in alcohol but the dyeings are not fast to light or rubbing. Acid dyes may be dissolved in alcohol and then diluted with benzine or Asordin, or dissolved in a mixture of alcohol and formic acid and diluted with chlorinated solvents. Some details are given. (Copied from *J. T. I.*, April 1936, P. A170.) (C)

OXYGEN BLEACHES. Fritz Ohl. *Spinner u. Weber*, 1936, V. 54, No. 9, P. 26–30.

The use of O-contg. bleaches is discussed. K water glass which is low in alkali concn. is better than the ordinary grades of Na water glass as alkalizing and stabilizing agents for H_2O_2 bleaching baths. No optimum concns. can be fixed for O bleaching baths, but these concns. can be detd. from a study of the textile material to be bleached and the particular conditions of operation. O-contg. bleaches do not have a greater fibre-damaging effect than have Cl bleaches. (From *C. A.*, 1936, V. 30, Col. 3245.) (W)

POTATO STARCH: SWELLING IN WARM WATER. E. Wiegel. *Kolloid Z.*, 1936, V. 74, P. 58–66.

An investigation of the swelling in warm water of potato starch, treated with acid, alkalis, and an alkaline earth, shows that the viscometrically recorded course of the paste formation, in particular, the position of the viscosity maximum, is dependent to a great extent on the nature and amounts of the contained bases. The conclusion is reached that there are two extreme types of commercial potato starches, alkali starches of high swelling capacity, generally obtained when a very soft water is used, and alkaline earth starches, swelling less readily, developed with hard waters. Viscosity curves for the swelling process are typical for the various starches, and may be used for their identification. (From *J. T. I.*, April 1936, P. A191.) (C)

PREPARATION AND TINCTORIAL PROPERTIES OF CERTAIN BENZOXAZOLE DYES. V. J. Mikeska and M. Taylor Bogert. *J. Am. Chem. Soc.*, 1935, V. 57, P. 2513–7; *C. A.*, 1936, V. 30, Col. 2009. (W)

RAW MERCERIZATION OR BOILING MERCERIZATION. Asu Vendor. *Monatschr. Textil-Ind.*, 1936, V. 51, P. 47–9.

The raw mercerization method offers no tech. difficulties and its many advantages over the boiling mercerization method are pointed out. (From *C. A.*, 1936, V. 30, Col. 4012.) (W)

RAYON FABRICS: PREPARATION OF—FOR DYEING. Hector C. Borghetty. *Am. Dye. Rptr.*, June 15, 1936, P. 320–21; *Am. W. & C. Rptr.*, July 2, 1936, P. 9–10.

Paper presented at meeting of Rhode Island Section of A. A. T. C. C., Jan. 24, 1936. (C)

RAYON: NEW METHODS FOR THE AFTERTREATMENT AND PARTICULARLY THE WASHING OF. A. Foulon. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 236, 238; *C. A.*, 1936, V. 30, Col. 2766. (W)

REDUCTION AND DISPERSION OF AZOIC DYES, ETC., IN PRESENCE OF LISSOLAMINE A (ICI). F. M. Rowe. *J. Soc. Dyers Col.*, June 1936, P. 205–8. (C)

RUST SPOTS: EASY REMOVAL OF—FROM TEXTILE MATERIALS. R. Brauckmeyer. *Deut. Wollen-Gewerbe*, 1936, V. 68, P. 458.

Rust spots can be removed more safely and quickly with NH_4HF_2 than with KHC_2O_4, dil. HCl, Sn salts, oxalic acid and others. Wet the rust spot, add a few grains of the salt which on going into soln. will remove the brown Fe stain, and wash well. (From *C. A.*, 1936, V. 30, Col. 3653.) (W)

SENSITIZING ACTION OF VAT DYES ON THE DEGRADATION OF CELLULOSIC FIBRES BY LIGHT. R. Haller and L. Wyszewianski. *Mell. Textilber.*, 1936, V. 17, P. 45–7, 138–40, 217–8, 325–26; *J. Soc. Dyers Col.*, June 1936, P. 236. (C)

SILK WEIGHTING. F. Weber. *Mell. Textilber.*, 1936, V. 17, P. 145–47, 224–25, 328–29; *J. Soc. Dyers Col.*, June 1936, P. 233. (C)

SIZING SUBSTANCES: SHORT SURVEY OF. A. M. Patel and N. C. Balsari. *Indian Tex. J.*, 1936, V. 46, P. 199–200; *C. A.*, 1936, V. 30, Col. 4327. (W)

IV. RESEARCH METHODS AND APPARATUS

COLOR MEASUREMENT IN TEXTILES. G. Furlonger. *Dyer*, 1935, V. 74, P. 577–8.

The Ostwald color system (cf. Scholefield, *C. A.*, V. 24, P. 3408) is described and criticized on the ground that it is based on Fechner's law, which has been shown to be inaccurate for very bright and dark colors. (From *C. A.*, 1936, V. 30, Col. 5796.) (W)

FLEECE-SAMPLING INSTRUMENT: AN IMPROVED. A. Blakey Wildman. *J. T. I.*, June 1936, P. T177–82.

Brief reference to earlier fleece-sampling instruments is made. Mention is made of a recent (1931) instrument, the Wyedesa caliper; and

its advantages and disadvantages are discussed. In the light of certain basic ideas derived from the Wyedesa instrument, a new fleece-sampling instrument, the Wira fleece caliper, was designed, constructed and tested. It is claimed that the Wira caliper is more accurate, easier and quicker to use than any fleece-sampling instrument previously devised. (C)

GELATINOMETER: NEW METHOD WITH THE AID OF THE—OF L. ZAKARIAS FOR EVALUATING GUMS, SIZING, THICKENINGS, ETC. Franz Kölbl and L. Zakarias. *Tiba*, 1936, V. 14, P. 249–55, 311–15.

The special value of the gelatinometer is that it can det. quanitatively and simultaneously, two properties of any kind of starch, namely, the thickening power and elasticity. It is suitable for albuminoids and other substances. Graphs are given showing the effect of aging and alkalies on the starches (rice and potato), gum tragacanth, bone and skin gelatin. (From *C. A.*, 1936, V. 30, Col. 6206.) (W)

GRADING RAW COTTON. Anon. *Tex. Recdr.*, Aug. 6, 1936, P. 25–6.

Describes the principles of polarization, the structure of the cotton fibre as explained by Osborne in *Tex. Rsch.*, 1935, *5*, 282, and the technique for the use of the polarizing microscope for cotton fibre maturity as given by Schwartz and Hotte, *Tex. Rsch.*, 1935, *5*, 370. (C)

HYGROSCOPIC MOISTURE OF CELLULOSE. XIII. INDIRECT DETERMINATION OF THE HEAT OF SORPTION OF WATER VAPOR ON CELLULOSE. S. Oguri and T. Yoshida. *J. Soc. Chem. Ind. Japan* 48 Suppl. binding, 1935, P. 434–36.

An apparatus is described which uses a chemical balance. Standard cotton cellulose was used for the experiments, and about 30 hrs. was required for establishment of the sorption equilibrium. Results at 15, 20, and 25° C are reported. The heat of sorption was calculated by means of the Clausius-Clapeyron equation, and data are presented for sample moisture of 6 to 16%. Graphs are shown for percentage of relative humidity. The points at different temperatures lie on a single curve for the temperature range covered when plotted against the relative humidity; this indicates that the sorption of water vapor will be almost independent of the temperature if the relative humidity is kept constant. (From *Paper Trade J.* Aug. 20, 1936, P. 30.) (C)

INFRA-RED PHOTOGRAPHY AS A TOOL IN TEXTILE CHEMISTRY AND THE TESTING OF TEXTILE GOODS. H. Reumuth and W. Köhler. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 315–20.

A review dealing with applications of micro- and macro-photography in the infra-red, illustrated with eight photographs of various fabrics showing highly degreased "porous" wool, fibres from a damaged mixed fabric, detection of chem. damage of aniline black cotton fibres, macro-detection of oxycellulose by Fehling's reaction, dark green woolen goods with suspected faulty dyeing, etc. (From *C. A.*, 1936, V. 30, Col. 5418.) (W)

MEASURE OF IMPERMEABILITY OF FABRICS. T. Maisoni. *Tiba*, 1936, V. 14, P. 175–9.

In a comparison trial using 3 com. waterproofing compds. (compn. not stated) and a water pressure test, it was found that impermeability

was not proportional to the concn. of the agent, and the influence of temp. was slight, but other auxiliary materials used can influence the water-proofing. (From *C. A.*, 1936, V. 30, Col. 6203.) (W)

MEASUREMENT OF THE LONGITUDINAL SWELLING OF STAPLE RAYON. W. Weltzien and J. Buchkremer. *Monatsh. Seide Kunstseide*, 1936, V. 41, P. 226–8, 230, 232; *C. A.*, 1936, V. 30, Col. 5798.

The method of measuring the length is given and the instruments used are shown and described. Curves show the swelling (change in length in %) of various grades of viscose and Cu rayons and staple rayon. The curves show a distinct difference between the swelling of viscose rayon and viscose staple rayon and also between the various grades of staple rayon. In the case of certain grades of staple rayon the shrinking is relatively small after the swelling with NaOH while in the case of other grades larger values are obtained which approach those found for viscose rayon. The study on Cu staple rayon showed a shrinking only occasionally and a distinct elongation in many instances. (W)

MEASUREMENT OF THE VARIATION OF THE DIELECTRIC CONSTANT OF WATER WITH EXTENT OF ADSORPTION. G. H. Argue and O. Maass. *Can. J. Rsch.*, Sept. 1935, P. 156–66.

An experimental technic was devised for the measurement of the dielectric constants of cellulosic materials containing various amounts of adsorbed water. From measurements made with standard cellulose the dielectric constant of the adsorbed water was calculated over the concentration range 0 to 18% of water. The dielectric constant of the water initially adsorbed is less than one-quarter of that of liquid water, but it increases with the amount of water subsequently adsorbed, until the dielectric constant approximates that of liquid water as the water content of the fibre approaches the saturation point. These results are shown to be in agreement with the hypothesis concerning the nature of the system cellulose-water. (From *Paper Trade J.*, Aug. 20, 1936, P. 30.) (C)

MICROSCOPIC EXAMINATION: SIGNIFICANCE OF THE—OF THE CROSS-SECTION OF TEXTILE FABRICS. Erich Wagner. *Z. ges. Textil-Ind.*, 1936, V. 39, P. 322–7.

A review accompanied by 21 drawings showing the cross-section of various grades of cotton, rayon, wool, and silk. The microscopic cross-sectional examns. are of particular importance in the fields of synthetic textiles and in differentiating between varieties of rayon. (From *C. A.*, 1936, V. 30, Col. 5419.) (W)